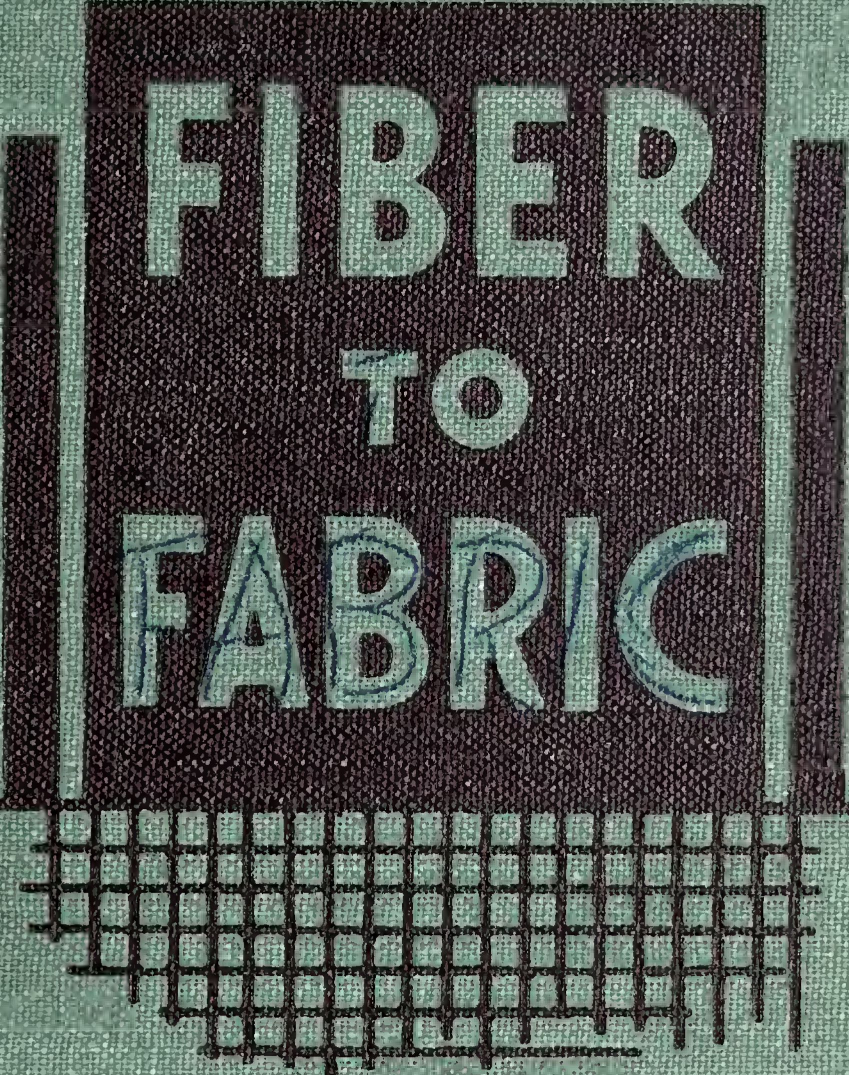

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# Fiber to Fabric

## A TEXTBOOK ON TEXTILES FOR THE CONSUMER

by

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GREGG PUBLISHING DIVISION

McGraw-Hill Book Company, Inc.
New York Chicago San Francisco Dallas Toronto London

# FOREWORD

Textiles, in various forms, constitute so large a part of merchandise that it is imperative that those engaged in merchandising, as well as students who expect to enter the field, be accurately informed regarding the basic fibers, the various manufacturing processes, and the characteristics of the finished fabrics.

*Fiber to Fabric* presents all this information authoritatively, interestingly, and simply. The unusually fine illustrations contribute eye-appeal as well as technical information.

Teachers, co-ordinators, supervisors, teacher trainers, salespersons, buyers, store-training personnel, and consumers will find the up-to-date contents of this book of practical interest.

G. Henry Richert
*Specialist in Distributive Education*
*Washington, D. C.*

FIBER TO FABRIC

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# PREFACE

The entire educational pattern has been challenged in recent years by a movement for consumer education. Practical subjects designed to educate the consumer regarding values are now included in the curriculums of progressive schools and colleges that have recognized this need. Today, many high schools are considering adding such subjects to their curriculums in order to fulfill the fundamental objectives of consumer education.

No defense is needed for this trend. The methods of achieving the aims of consumer education, however, are under question. A practical subject such as textiles, for example, is taught in two ways. One method emphasizes technical data and burdens the consumer with many manufacturing operations and manufacturing details. This method is not selective enough. The consumer does not need a great amount of technical data in order to buy intelligently. In certain respects, the broad scope of the commodity approach is necessary only for those who expect to be associated with an industry in a vocational capacity.

The other method goes somewhat to the opposite extreme. Factual data are considered burdensome and wholly unnecessary, and analyses of ingredients and details of methods of construction and finishing are avoided. The proponents of this method argue that all that the consumer needs to know—and cares to know—is "what to buy" and "what not to buy"; that he is willing to follow blindly trade-marked names, commercial advisory services, or the opinion of a salesperson who has been given special training. This functional approach does have points in its favor.

It is not possible, however, to establish a minimum of facts that will cover a subject to the complete satisfaction of every person. It is difficult to distinguish between what may be considered essential facts and what may be termed burdensome data. The consumer does not need to know, for example, the name of each machine and of each operation that manufactures and processes the article he contemplates purchasing. Also, even among those consumers who are interested in some technical information, the amount of information desired will vary.

There are differences in the levels of consumer education. No short-cut method will reach them all. Indeed, the result of such a method will be so superficial that more harm than good may be done. But this does

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not mean that all manufacturing details must be digested by each consumer. Possibly, simplified treatment of a subject is the answer, for simplification provides a basic understanding for those who do not wish to pursue a subject further, and it whets the appetite of those who desire additional knowledge.

It is hoped that the subject of textiles has been thus simplified in this book. The first chapters can hardly be called technical; but they do endeavor to cover completely the basic qualities of the major fibers, because fibers are the ingredients of fabrics. When the consumer is thoroughly acquainted with the differential qualities of fibers—when he studies yarns and weaves and how a fiber takes a dye, or understands that finishing processes may contribute something that a fiber lacks—he can decide for himself what value may be expected from any type of finished fabric. He can answer his own questions: What is this fabric made of? Just how good is it? Will it serve my purpose? Am I receiving full value for the price I am paying?

*Acknowledgments.* This book is the development of a course of study in textiles that the author was invited to initiate at the College of the City of New York in order to establish a methodology for teachers of textiles. Appreciation is hereby expressed to Professor Arthur E. Albrecht, Chairman of the Department of Business Administration, for his cooperation.

Acknowledgment is also due the following:

Sylvan S. Stroock, President of S. Stroock & Company; S. C. Carse, President of York Street Flax Spinning Company; Dr. Claudius T. Murchison, President of Cotton Textile Institute, Inc.; L. A. Beers, President of the Institute of Carpet Manufacturers of America; Dr. William E. Coughlin, Director of Textile Laboratories of Good Housekeeping Institute; Irene L. Blunt, Secretary of the National Federation of Textiles; R. C. Ball, Secretary of the National Association of Hosiery Manufacturers; John V. Smeallie, Defense Director of the Mohawk Carpet Mills, Inc.; Harry S. Radcliffe, Secretary of the Linen Trade Association; Solomon Jacobson, Associate Regional Economist of the Office of Price Administration.

A list of the firms who generously supplied illustrative material appears on page 307.

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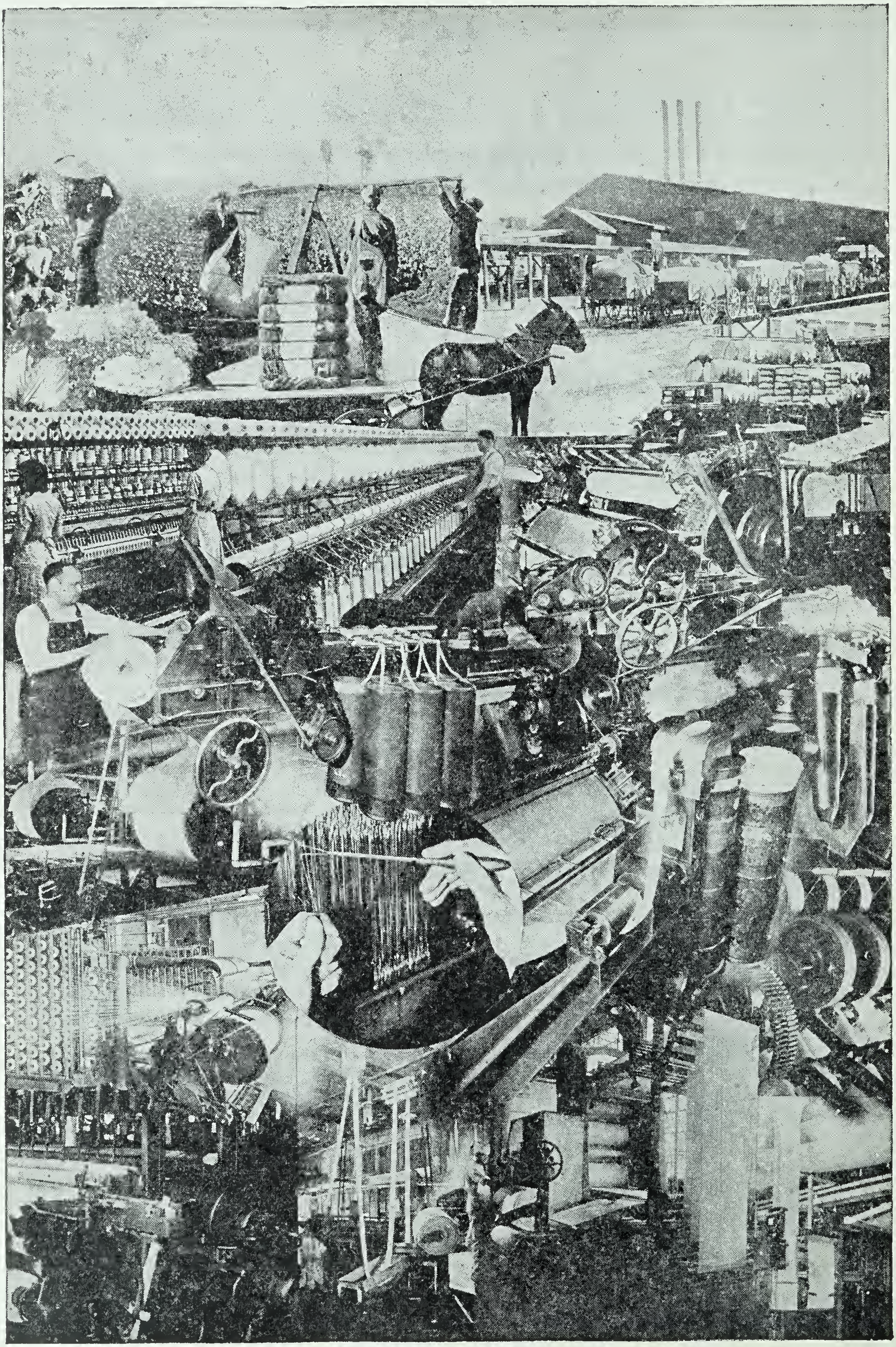


Cotton—from fiber to fabric.

## CHAPTER I

# DIFFERENTIAL QUALITIES OF TEXTILE FIBERS

Some knowledge of textile materials should be invaluable to everyone because textiles have such important bearings on our daily lives. From earliest times, man has used woven fabrics for covering, warmth, personal adornment, and even to display personal wealth. Fabrics both useful and beautiful have been used as draperies in primitive thatched hut and in cold stone palace to provide warmth as well as decoration.

Today, fabrics are still used for these two main purposes. Everyone is an ultimate consumer of textile materials; he uses textiles in some form even if he is not the direct purchaser. Included among consumers are merchandisers of many types, from the wholesale textile manufacturer and merchant to the retail store sales force. Many of the industries—for example, the automobile industry—are important consumers of textiles in various forms. Other consumers are homemakers, dressmakers, interior decorators, and retail store customers, as well as students who are studying for these and various other occupations and professions in which a knowledge of textiles is of major importance.

The merchant, particularly, and all those who work for him must be thoroughly familiar with the merchandise they are handling if they wish to be successful in the mercantile field. Only thorough knowledge will prevent the mistakes that are often made in buying and selling.

**Reasons for Studying Textiles.** A study of textiles shows why certain fabrics are more durable and therefore more serviceable for specific purposes. This study reveals how certain fabrics keep a person cool as well as give an impression of coolness when used as decoration. The quality of cleanliness may be estimated before purchasing, when that quality is an important factor.

Complete knowledge facilitates an intelligent appraisal of standards and brands of merchandise and develops the ability to distinguish quality and, in turn, to appreciate the proper uses for the different qualities. As a result, the consumer merchant and the consumer customer know how to buy and what to buy, and salespeople know how to render good service to those consumers who have not had the advantage of a formal course in textiles.

In the study of textiles, the initial interest of the student will become an absorbing one when he discovers the natural fascination of fabrics and their cultural associations, particularly when factual study is supplemented by the handling of actual textile materials. The subject will seem worth while to the student when he becomes familiar with illustrative specimens and fabrics and handles and compares raw materials as well as finished consumers' goods.

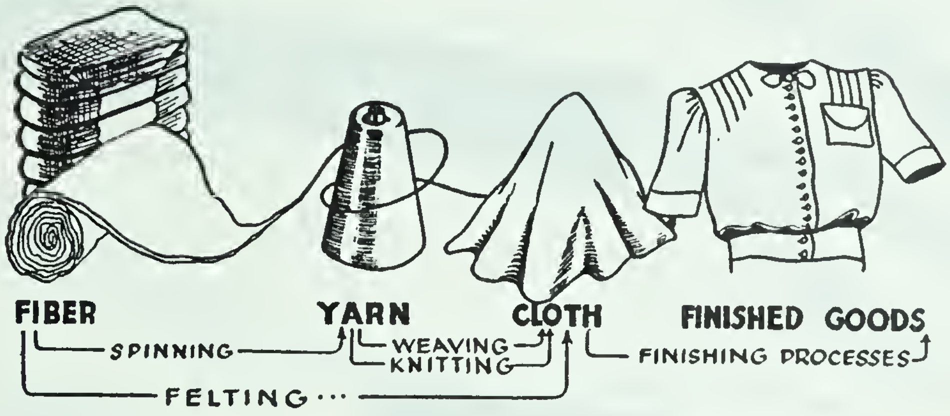
**Sequence of Cloth Construction.** In beginning the study of textiles, the student should have in his hand a sample of a *woven fabric*. He should examine the sample closely. He should note that it is constructed by means of an interlacing of sets of yarns that run lengthwise and crosswise. A closer examination of any one of these yarns reveals the fibrous substance from which the yarn is made. Such fibers comprise a multitude of filaments that have been separated, drawn out, and twisted together to form yarns. It is from the interlacing, or weaving, of yarns that most textile materials are made.

There is a logical development of raw material into finished consumers' goods. Although the student holds in his hand the woven fabric as the consumer sees it, and as it appears when ready for mercantile use, he must study textile materials in the interesting sequence of "fiber to yarn to cloth" in order to understand the construction and ultimate qualities of the fabrics with which he will become familiar.

The steps in the manufacture of fabrics, from raw material to finished goods, may be summarized thus:

1. *Fiber,* which is *spun* into *yarn* or directly *felted* into *cloth.*
2. *Yarn,* which is *woven* or *knitted* or *braided* into *cloth.*
3. *Cloth,* which by various *finishing processes* becomes *finished consumers' goods.*

The scope of this development from raw material into finished consumers' goods is also indicated by the following sketch, which should help the student to visualize the entire field of textile manufacture—from fiber to yarn to cloth to finished goods.



**Kinds of Fibers.** The textile industry uses many different kinds of fibers as its raw materials. Some of these fibers were known and used by mankind in the earlier years of civilization as well as in modern times. Other fibers have become important in recent years. New man-made fibers are being produced and tested daily. Some fibers have assumed importance from time to time because of some specific quality, such as low cost production, which is always a factor in the business world.

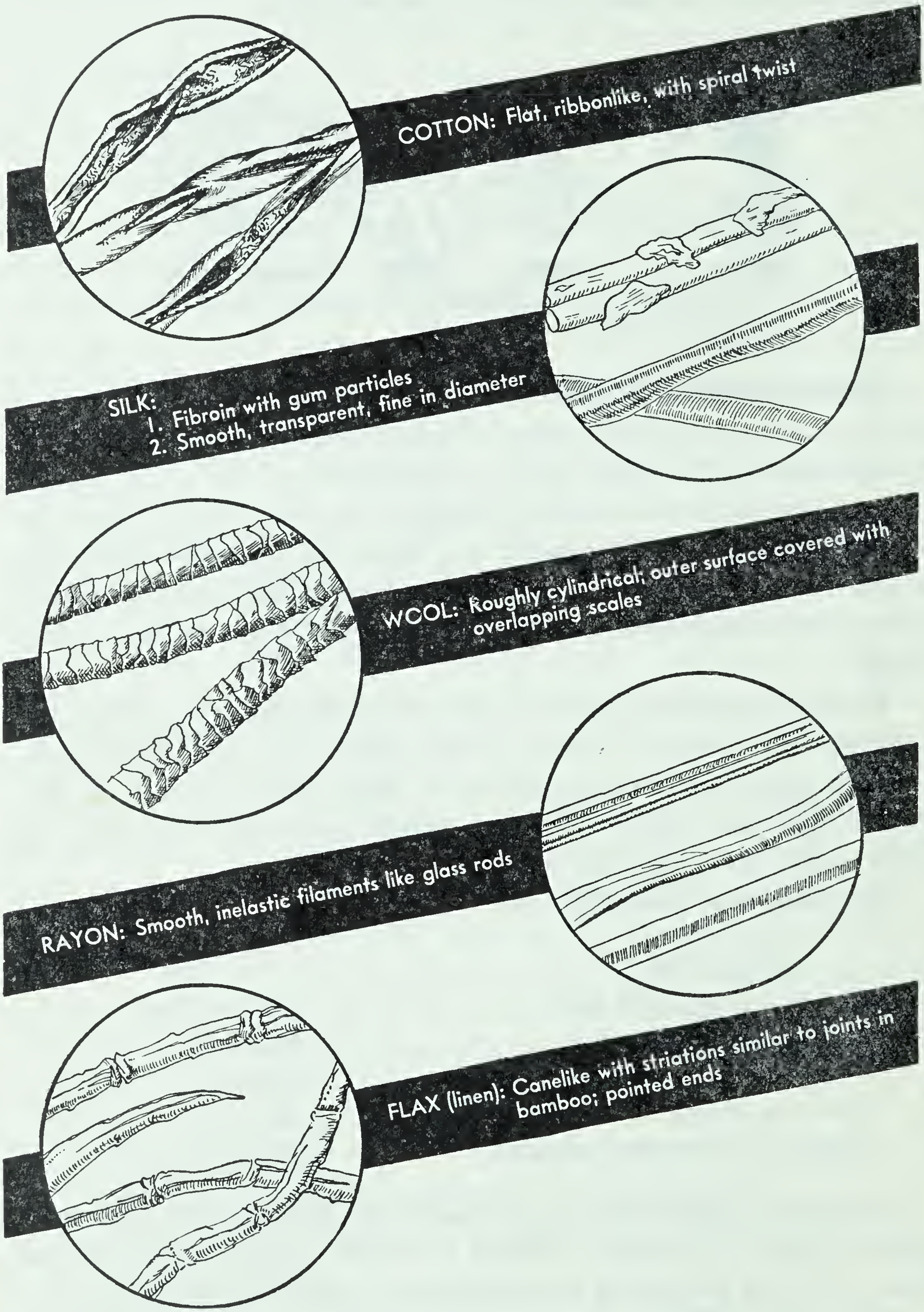
From a commercial point of view, and judging from quantity use, there are five principal fibers—cotton, linen, wool, silk, and rayon. The description and the comparison of these major fibers show that their commercial values depend on certain properties that make the fibers usable for consumers' needs.

The sources of these fibers are:

| *Major Fibers* | *Sources* |
|---|---|
| Cotton—a vegetable fiber | Cotton plant |
| Linen—a vegetable fiber | Flax plant |
| Wool—an animal fiber | Sheep |
| Silk—an animal fiber | Silkworm |
| Rayon—a man-made product | Trees and plants |

Additional animal fibers—such as camel's hair, mohair, cashmere, alpaca, llama, and vicuna—as well as certain vegetable and mineral fibers, also lend themselves to various uses in the textile industry.

**Properties of Fibers.** In order to identify the major fibers, the consumer must understand their separate properties. This knowledge will


COTTON: Flat, ribbonlike, with spiral twist
SILK:
1. Fibroin with gum particles
2. Smooth, transparent, fine in diameter
WOOL: Roughly cylindrical; outer surface covered with overlapping scales
RAYON: Smooth, inelastic filaments like glass rods
FLAX (linen): Canelike with striations similar to joints in bamboo; pointed ends

The structure of fibers.

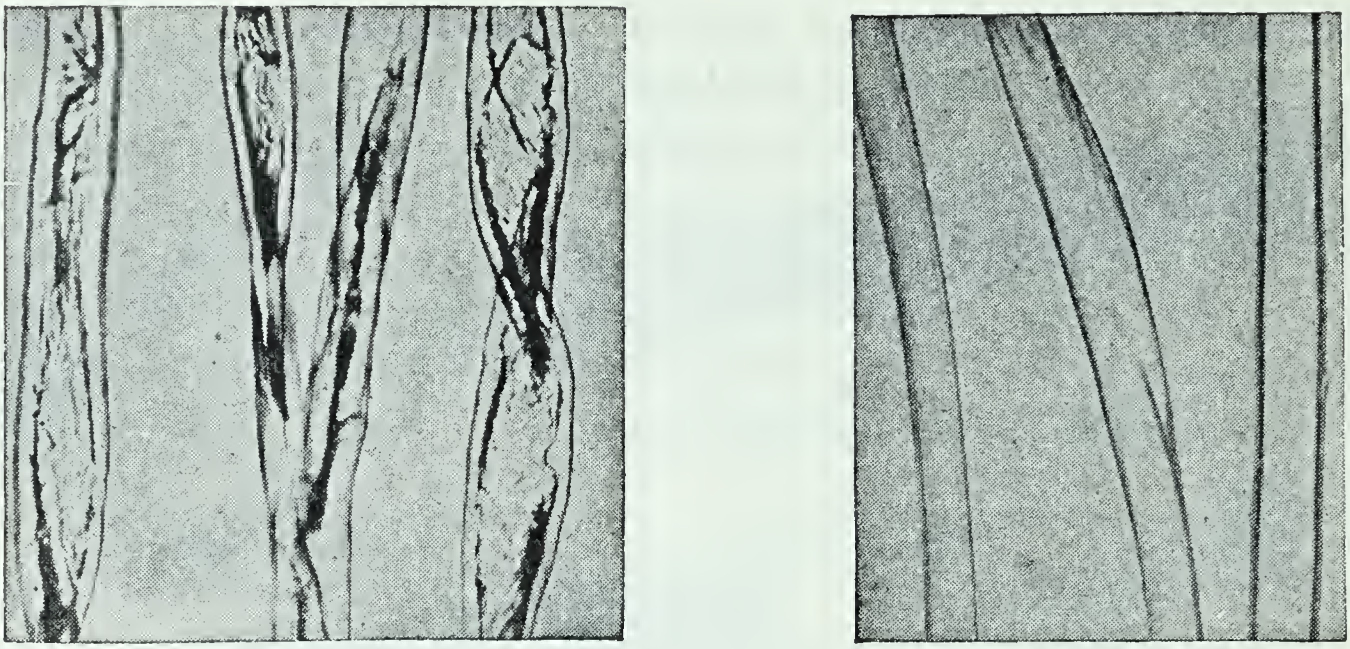
even increase the consumer's use of the finished goods. The commercial value of any fiber depends largely upon the extent to which it possesses certain properties or qualities. Some of the most important properties are tensile strength, elasticity, fineness, cohesiveness, and sufficient length—all of which facilitate the process of spinning into yarn. Fibers must also have some degree of porosity in order to permit the absorption of bleaching and dyeing liquids. These various properties are studied in the following order:

1. Structure
2. Length
3. Strength
4. Elasticity
5. Heat conductivity
6. Absorbency
7. Cleanliness and washability
8. Luster
9. Affinity for dyes
10. Fineness of diameter
11. Reaction to alkalies and acids

**Structure of Fibers.** Each textile fiber has its own distinctive structural markings that, under a microscope with a magnification of at least 100, supply an absolute identification of the fiber. Certain general observations also make it possible to identify fibers without the use of a microscope. These differences in structure determine the various characteristics of the different fibers and the reasons why some fibers are to be preferred to others for certain uses.

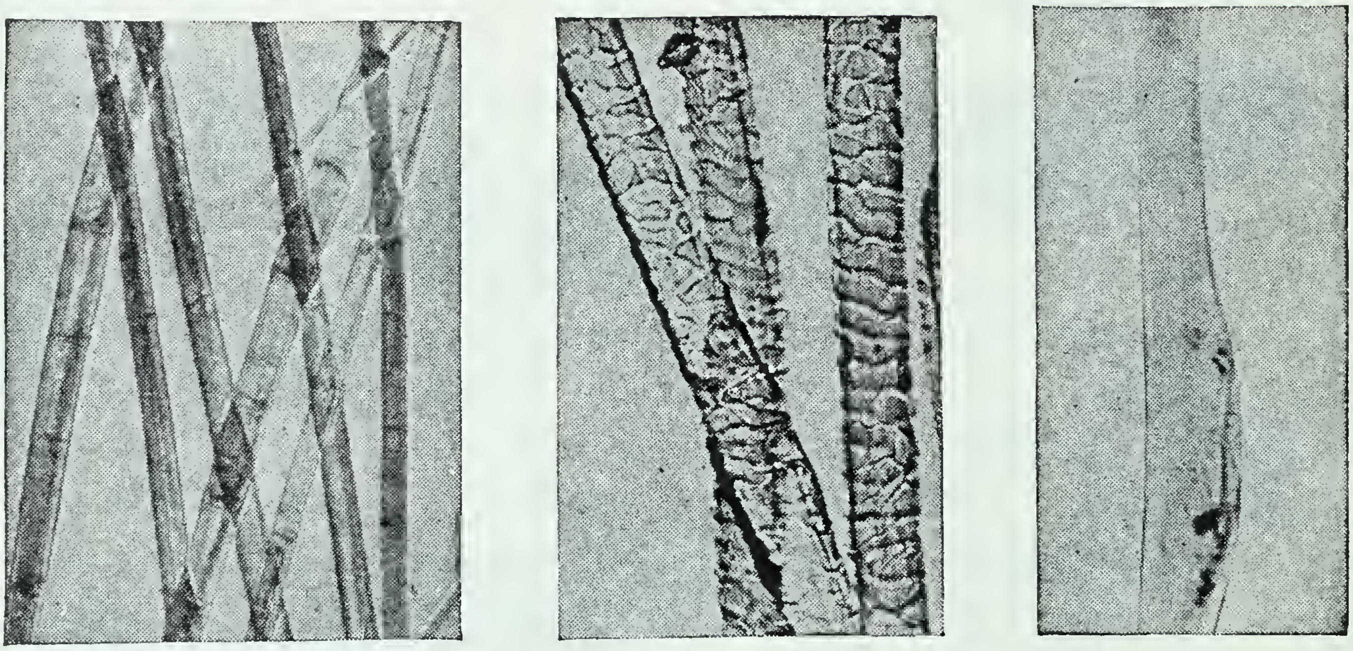
*Cotton Fiber.* Unlike other fibers obtained from plants, cotton consists of a single elongated cell. Under the microscope, the fiber resembles a collapsed, spirally twisted tube with a rough surface and no luster. The thin cell wall of the fiber has from 200 to 400 turns of natural twist, or convolutions, to the inch. The fiber appears flat, twisted, and ribbonlike, with a wide inner canal and a granular effect. Chemically, the fiber contains about 90 per cent cellulose and about 6 per cent moisture; the remainder consists of natural impurities. The outer surface of the fiber is covered with a protective waxlike coating, which gives the fiber a somewhat adhesive quality.

Because of the natural twist in cotton fiber, the fibers may be easily spun into yarn. Some cotton fibers, however, look different under the microscope and do not have this natural twist. Such fibers have been subjected to the commercially important process of mercerization, which will be explained in Chapter V.



*a.* Cotton fiber

*b.* Cotton fiber after mercerizing



*c.* Linen fiber

*d.* Wool fiber

*e.* Silk fiber

Textile fibers under the microscope.

By this process of mercerization, the naturally flat, twisted cotton fiber swells and becomes straight, smooth, and round. The straightness of the fiber causes light to be reflected on the smooth surface and produces a lustrous effect that is commercially valuable. The resultant fabric is called *mercerized cotton.*

*Flax Fiber.* Under the microscope, the flax fiber shows hairlike cylindrical filaments with fine pointed ends. The filaments are cemented together at intervals in the form of markings, or nodes, by a gummy substance called *pectin.* The long flax filaments contain a lumen, or inner canal, which shows as a narrow line. The fiber resembles a bamboo stick, having a natural unevenness that cannot be eliminated. Chemically, the flax fiber is composed of about 70 per cent cellulose and about 25 per cent pectin; the remainder consists of woody tissue and ash.

From such fibers, linen yarns are produced that, to the naked eye, appear smooth, straight, compact, and lustrous. Linen fibers are more brittle than cotton fibers.

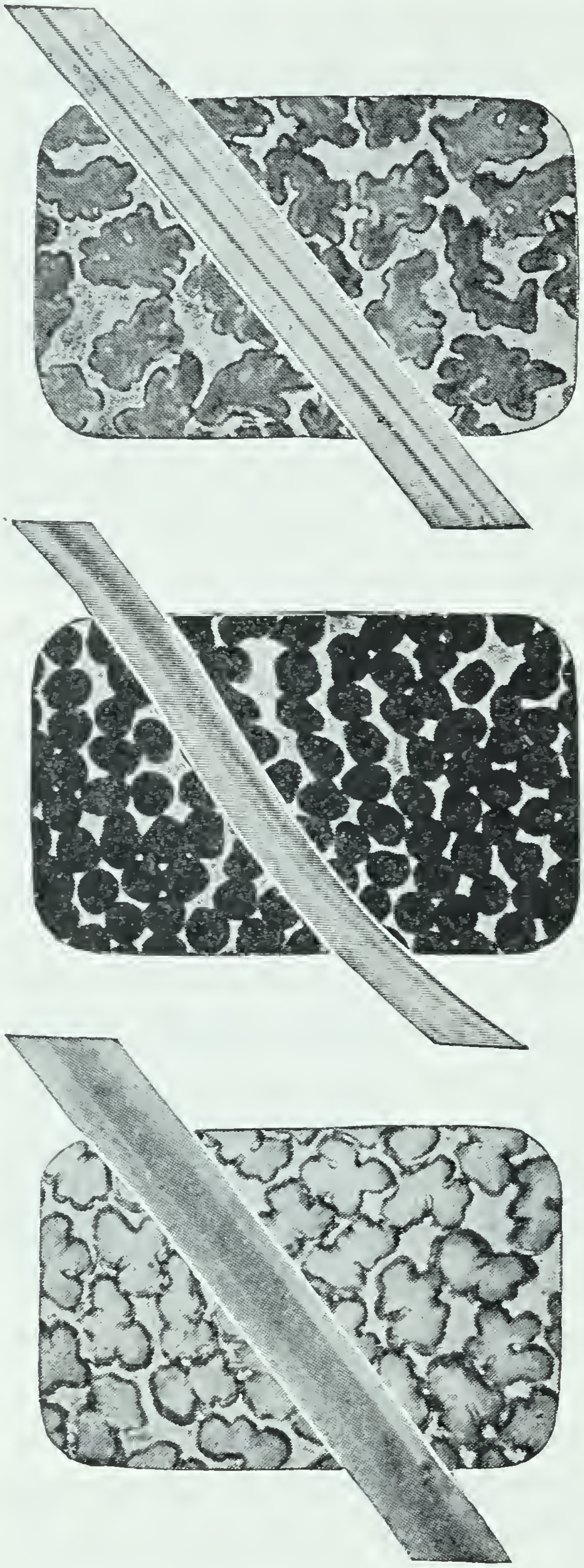
*Wool Fiber.* Wool fiber is irregular and roughly cylindrical, tapered at the end, and multicellular in structure. Under the microscope, a cross section shows three fundamental layers. The epidermis, or outer layer, consists of scales or flattened plates, ranging from 1,000 to 4,000 to an inch. These scales give the fiber its cohesive quality. They vary in type, from those having straight edges to those having marked wavy serrations; the former type is used for fine wools and the latter for coarse wools.

The second layer, the cortex, is the main fiber body and gives strength and elasticity to the fiber. The cortex consists of intermediate cells that hold the color pigment.

The innermost layer is the medulla, which consists of large air-filled cells. The medulla is discernible only in coarse and medium wools and only under high magnification. It is the central canal, varying in appearance from a narrow to a broad line or from a continuous to an interrupted line. Some wool fibers that have no cortical layer are compensated with a larger proportion of medullary cells; this fact lessens the affinity for dyes, because the medulla has more fat than has the rest of the fiber. The finer wools, having no medulla, absorb dyes more readily.

Chemically, wool is the only natural fiber that contains sulphur. It is composed of the following basic elements: carbon, 49.25 per cent; oxygen, 23.66 per cent; nitrogen, 15.86 per cent; hydrogen, 7.57 per cent; sulphur, 3.66 per cent.

Two striking characteristics of wool fiber are its susceptibility to heat and its felting property, which is caused by the horny epidermal scales. Because of this felting property, only pressure, heat, and moisture are required to make wool fibers into the type of fabric called *felt.*



*Top:* Viscose rayon fiber and its cross-section view under the microscope. *Center:* Cuprammonium rayon fiber and its cross-section view under the microscope. *Bottom:* Acetate rayon fiber and its cross-section view under the microscope.

*Silk Fiber.* Under the microscope, the raw silk fiber from cultivated cocoons appears as double cylindrical filaments with slightly varying diameters. These filaments are held together with an outer covering of a gummy secretion called *sericin.* The filaments are solid, smooth, and dull, with no grooves or lines. When the sericin is removed by hot water or steam, the two filaments appear clearly as fine, lustrous, uniform, transparent tubes, which are referred to as *fibroin.*

Wild silk, or tussah silk, may be distinguished from cultivated silk by its coarse, thick form, which appears flattened. Cultivated silk is a narrow fiber with no markings; wild silk is a broad fiber with fine, wavy longitudinal lines running across its surface, giving it a characteristic dark hue under the microscope.

*Rayon Fiber.* Rayon fiber is a synthetic, or man-made, fiber derived from cellulose, an inert, formless white substance found in the cell walls of all plant life. Because rayon fiber is man-made, there are several varieties. Their filaments differ according to the process used in their manufacture. Rayon fiber, in general, is easily recognized under the microscope by its glasslike luster and uniform diameter. The appearance of fine pepperlike particles on a cross-section view is an indication that the rayon has been delustered.

Rayon is the name given to the several types of man-made fibers that have a cellulose base. Synthetic fibers are also obtained from raw materials other than cellulose. In this study, such other man-made fibers are classified as noncellulose, as they are derived from such sources as coal, glass, asbestos and other minerals, soybeans, and even skim milk. Nylon, for example, because it has a mineral base, is one of the noncellulose man-made fibers described in Chapter XIII.

In the textile industry today, rayon fibers are classified as regenerated and nonregenerated.

*Regenerated rayon* is so named because its raw material, cellulose, is put through certain chemical changes that produce one substance, which is then regenerated into a purified state. There are three kinds of regenerated rayon: viscose, cuprammonium, and nitrocellulose.

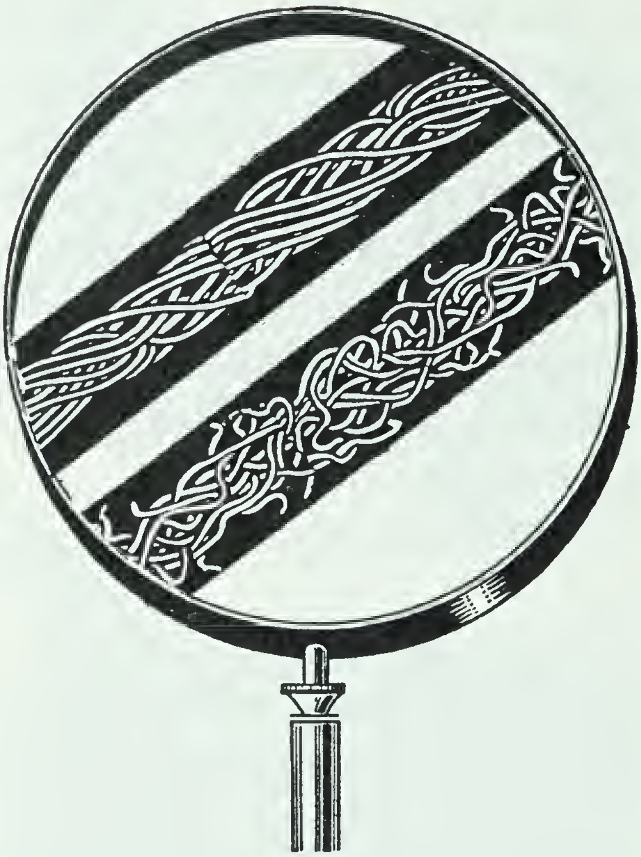
*Viscose,* under the microscope, shows many threadlike longitudinal lines that are spiral and somewhat glossy. A cross-section view shows a serrated edge.

*Cuprammonium* shows no markings. It is fine and glossy and resembles silk more closely than other fibers. The cross-section appearance is small and nearly round.

*Nitrocellulose,* the third kind of regenerated rayon, is not manufactured to any great extent because of the high cost of the chemicals. In the history of man-made fibers, however, nitrocellulose rayon is important because it was the first synthetic textile fiber to be produced.

*Nonregenerated rayon* is a compound of cellulose that possesses different qualities from those of the regenerated rayon. The fibers are fine and have line markings. They are less lustrous than the fibers of viscose or cuprammonium and sometimes show a central groove under the microscope. The cross-section appearance is bulbous, with indentations. The resultant fabric is called *acetate* or *cellulose acetate.*

The now familiar term *spun rayon* does not denote another type of rayon fiber. It is a trade name that may refer to both the regenerated and the nonregenerated products when the naturally long filaments are cut into shorter lengths and processed to produce a yarn with different qualities and an altogether different appearance from that of long-filament rayon.



**Length of Fiber.** When fibers are spun into yarn, they are made to lie parallel, and are drawn out and twisted to form a continuous yarn. If the fibers are long, there will be fewer ends in the twisted yarn. Fewer surface ends result in a smoother fabric, which naturally has less attraction for dirt particles. The smooth surface also helps to give an attractive luster to the finished cloth. Short fibers cause more surface ends and more points of potential separation, thus making a relatively weaker fabric.

The length of the fiber, termed *length of staple,* is, therefore, of fundamental importance in textiles. This fact has given rise to the expression, "The longer the fiber, the stronger the yarn." This statement, however, is true only when fibers within a single group are compared; for example, two or more wool fibers or two or more cotton fibers. A comparison of wool with cotton reveals that the wool fiber, although longer than the cotton fiber, is not stronger.

Long-staple yarns within each group of fibers produce stronger, smoother, more serviceable fabrics that cost more than the less durable fabrics made from short-staple yarns. In wool, for example, the short-staple fiber is used in the manufacture of woolens, and the longer staple is reserved for worsteds. Worsteds are considered more serviceable. A similar distinction is found in every textile fiber.

The sequence of fibers according to comparative length is as follows:

1. *Rayon.* Because rayon is a man-made product, rayon filaments may be made as long as desired, producing smooth-surfaced fabrics with no loose ends. The long filament is known in the textile industry as *continuous filament rayon*; the short filament is called *staple rayon,* or *spun rayon.*

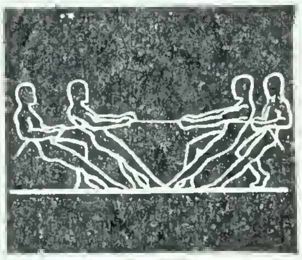
2. *Silk.* Raw silk fiber from cultivated cocoons is the longest of

natural fibers. It consists of a continuous fiber that varies in length from 1,200 to 4,000 feet. It produces a smooth, lustrous fabric.

3. *Linen.* The flax fiber is longer than the cotton fiber and the wool fiber, ranging from 12 to 40 inches. This length accounts for the absence of lint in linen fabrics.

4. *Wool.* The length of the average woolen staple varies from 1 to 4 inches. Worsted yarns are made from staple fibers that are over 4 inches in length.

5. *Cotton.* Cotton fiber is the shortest of all fibers, varying from ½ inch to 2½ inches. The bulk of the domestic cotton crop ranges from ¾ inch to 1½ inches in length.



**Strength of Fibers.** Fibers differ in their resistance to tearing apart when subjected to tension. The serviceability and durability of a fabric, therefore, cannot be determined by the length of staple alone. Tensile strength is a prime necessity in fibers if the resultant fabric is to stand the strain of wear.

The sequence of fibers according to tensile strength is as follows:

1. *Silk.* When the extremely small diameter of the silk fiber, which varies from .001 to .005 inch, is taken into consideration, silk is the strongest of all textile fibers. The breaking strength of raw silk is equivalent to nearly one-third of the breaking strength of the best iron wire of the same size. Silk surpasses all other natural fibers in lightness, resiliency, and strength.

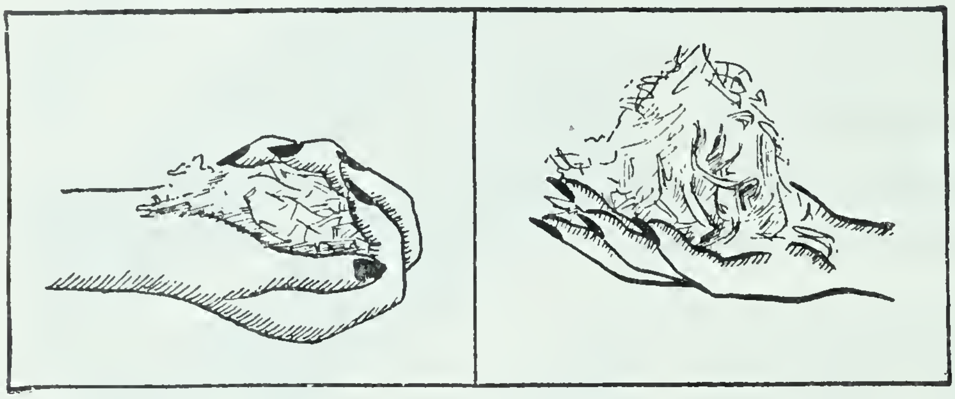
2. *Linen.* The flax fiber is second in strength to silk and is especially durable.

3. *Cotton.* Cotton has good tensile strength, being stronger than wool or rayon. Its strength may be increased by mercerization.

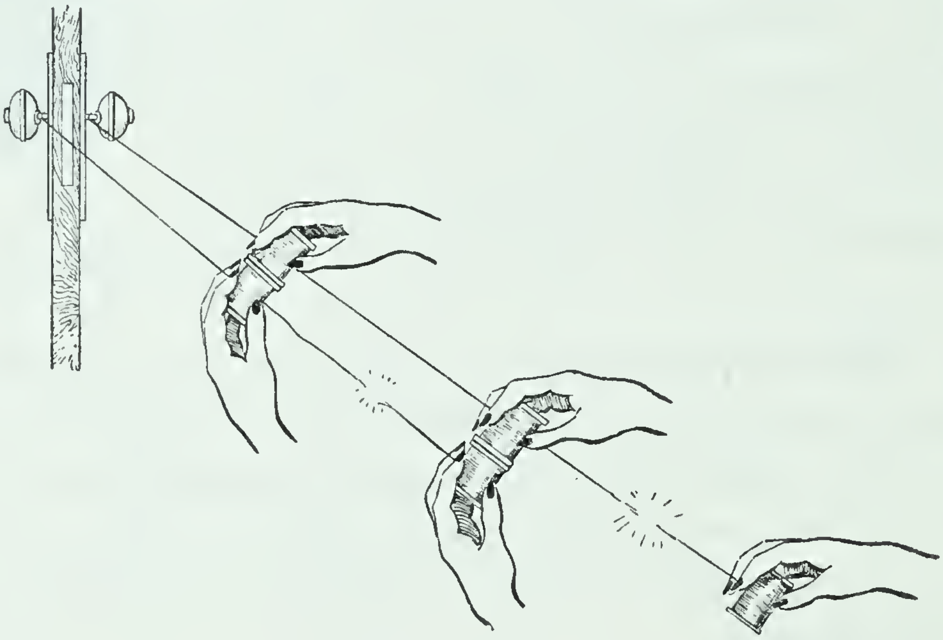
4. *Rayon* (*when dry*). The strength of rayon fiber is conditioned by its moisture content. When wet, rayon loses from 40 to 60 per cent of its natural strength, but this strength is completely regained when the fiber is dry. Acetate rayon, when wet, loses less strength than do the regenerated rayons. Rayon is therefore not considered a weak fiber because it is judged by its natural strength when dry, which is one-half to one-third that of silk.

5. *Wool.* Wool is the weakest of the major textile fibers. It has

low tensile strength; but when its diameter and lightness are considered, wool fiber may be called strong.



**Elasticity of Fibers.** When a fiber is elastic, the yarn is springy; and the resultant fabric will be resilient. This resiliency causes the fabric to be wrinkle-resistant, the resistance varying according to the degree of elasticity inherent in the fiber. As elastic fibers resist tearing, this quality of elasticity contributes to the strength of a fabric. It also permits materials to drape well on the human figure. Elasticity facilitates the spinning process, as inelastic fibers break more easily than do elastic fibers.



Comparative elasticity of silk and cotton may be tested by attaching silk and cotton yarns to a fixed object. Hold both yarns taut. Pull slowly until each yarn breaks. Cotton breaks first as it lacks elasticity. Silk breaks only after considerable stretching because of its elasticity.

Fibers that are naturally inelastic, however, can be given a degree of elasticity by reducing them to short staple. Short-staple yarns contribute softness to a fabric, helping to make the fabric somewhat crease-resistant; but some strength is sacrificed. A chemical finish can be used to obtain crease resistance. This method is preferable because it does not affect the strength of the fiber.

The sequence of the major fibers according to elasticity is as follows:

1. *Wool.* Wool fiber has natural elasticity. It can be stretched one-third of its original length. Because of this high degree of elasticity, wool fabric wrinkles less than any other material.

2. *Silk.* Silk fiber also has natural elasticity. It can be stretched from 15 to 20 per cent of its original length before breaking.

3. *Cotton.* As cotton fiber is inelastic, fabrics made from cotton wrinkle easily. When a piece of cotton cloth is creased with the fingernail, the crease is retained; silk and wool are not so easily affected. Fingernail creasing may serve as a test, therefore, to distinguish silk and wool from cotton and linen.

4. *Linen.* The flax fiber is also naturally inelastic. Linen fabrics wrinkle and crease easily. Linen fiber may be made more crease-resistant by reducing it to short staple.

5. *Rayon.* The normal elasticity of rayon fiber is very low. Rayon yarns made of the finer filaments are somewhat flexible, but coarse filaments crease readily. Spun-rayon fabrics are wrinkle-resistant because of their soft texture, produced by short-staple fibers.

**Heat Conductivity of Fibers.** The quality of a fiber to conduct heat, or to act as a nonconductor of heat and therefore serve an insulative purpose, has tremendous significance in textiles. The degree of heat conductivity determines whether fabrics are suitable for winter or for summer use.

In addition to the heat conductivity inherent in the fiber, the weaving, knitting, and finishing processes affect this quality. When a fabric is loosely constructed, for example, it has air spaces, which have an insulative property. Also, the captive air pockets contained in a napped surface add warmth to a fabric.

The sequence of fibers according to heat conductivity is as follows:

1. *Linen.* The flax fiber is the best conductor of heat. Linen fabric is therefore most suitable for summer apparel, as it allows the heat of the body to escape easily and quickly.

2. *Cotton.* Cotton fiber is a good conductor of heat. Cotton fabrics

are also suitable for summer clothing. The surface of the cloth has much to do with the degree of heat conductivity.

3. *Regenerated rayon.* Rayon is a good conductor of heat and is appropriate for summer wear. Spun rayon, which has a napped surface, has a warmth-giving effect.

4. *Acetate rayon.* Acetate rayon differs from the regenerated type in that it is a nonconductor of heat. Acetate resembles silk in this respect and is suitable where warmth is required.

5. *Silk.* Silk is always a nonconductor of heat and may be used for winter clothing.

6. *Wool.* As nonconductivity of heat is necessary for the purpose of warmth, wool ranks highest as a nonconductor.

**Absorbency of Fibers.** The quickness with which a fabric absorbs moisture and gives it up again in evaporation has an important bearing on health and comfort. Textile fibers vary in their natural absorptive capacity, but absorbency may be increased by cloth construction or by a finishing process. A loosely constructed fabric or one with a napped surface, for example, is more absorptive than a smooth-surfaced fabric.

Under standard conditions of heat and moisture (70 degrees Fahrenheit and 65 per cent relative humidity), the sequence of fibers according to comparative absorbency is as follows:

1. *Wool.* Wool fibers absorb moisture quickly and hold a large amount, allowing it to evaporate slowly. Wool is thus an ideal fabric for bathing apparel, as this slow-drying quality permits body adjustment without adverse effect. When wet, wool does not stick to the body and is also ideal for outer wear on cold, damp days. The natural moisture content of wool ranges between 12 and 16 per cent.

2. *Silk.* Silk fiber absorbs moisture readily and, like wool, can hold much water without feeling wet.

3. *Regenerated rayon.* The absorbency and drying qualities of regenerated rayons are closely akin to those of silk. The natural moisture content of regenerated rayons is 12 per cent.

4. *Linen.* Linen absorbs moisture more quickly than cotton and dries more quickly than any other textile fiber. For this reason it is excellent for towels and handkerchiefs. The natural moisture content

of linen is about 8 per cent. The humidity of the environment will even increase this percentage.

5. *Cotton.* Cotton absorbs water less readily than other textile fibers and dries quickly. When wet, cotton feels cold and clammy. Its natural moisture content is 6 to 8 per cent. A napped surface always increases absorbency.

6. *Acetate rayon.* Acetate rayon absorbs moisture slowly and dries quickly. Its natural moisture content is 6.5 per cent. As this is half the moisture content of regenerated rayon, acetate has preference wherever the fast-drying quality is desired.

**Cleanliness and Washability of Fibers.** The consumer is interested in knowing what textiles are hygienic, how long a garment may be expected to remain clean, and whether it will require unusual care when laundering or dry cleaning is necessary. The fibers that show smooth surfaces under the microscope produce fabrics that are easy to launder; thus garments made of linen, silk, and rayon wash easily. A napped surface on any one of these materials makes it necessary to give the garment more care in washing.

The sequence of fibers according to comparative cleanliness is as follows:

1. *Linen, silk, rayon.* These three fibers are named together, as the factor of cleanliness is approximately the same for each. The construction and finish of the resultant fabrics have an important bearing on how these three fibers can be judged separately.

Because of the smooth surface of its fiber, linen gives up stains readily and affords little adhering surface for particles of dirt. Bacteria do not thrive on linen. Linen launders well; its softness is enhanced by repeated washings.

Silk makes a hygienic material because its smooth surface and absence of short fiber causes it to shed dust and to give up dirt readily. If handled properly, silk can be washed easily.

Although dirt particles may be easily removed from rayon fiber, care must be taken to avoid undue strain on the material when rayon garments are being washed. Rayon loses much of its strength when wet, but regains it entirely when dry.

2. *Cotton.* The short cotton fiber produces a fabric with a relatively rougher surface than that of linen, silk, or rayon and therefore soils easily. Nevertheless, cotton fabric is considered a hygienic material because it can be cleaned easily—it withstands rough handling and boiling temperature.

3. *Wool.* The serrated surface of the outer scales of the epidermis of wool fiber attracts dust, bacteria, and dirt particles. Consequently, wool fabric requires frequent dry cleaning or washing if the nature of the cloth permits it. Wool fabrics that have a high grease content must not be washed; they must be dry-cleaned. Wool fiber is softened by moisture and heat, and therefore the fabric shrinks easily; felting occurs when wool is washed improperly. A wool garment should not be rubbed or handled like a cotton one.

**Luster of Fibers.** Luster is produced by the reflection of light from a smooth surface. A lustrous effect in fabrics adds to their attractiveness, and in some cases may be absolutely necessary, depending on the purpose of the fabric. On the other hand, luster may not be desired, as in napped or crepe surfaces. An appropriate lustrous effect, however, is a generally desired quality.

Degrees of luster are obtained in several ways. The use of long-staple yarns produces a smooth surface, which will have a natural luster. The use of caustic soda in the mercerizing process is a chemical method of producing luster. The satin weave and certain finishing processes are also used for this purpose.

The sequence of fibers according to comparative luster is as follows:

1. *Rayon.* Rayon is a naturally lustrous fiber. In the early days of rayon production, the yarn had too much luster. At that time, a dulling effect was obtained by twisting the yarns or by using a calcimine coating as a final finish. Today, rayon is more easily delustered by using colorless pigments in the spinning solution. The short staple used in the production of spun rayon automatically delusters spun-rayon fabrics.

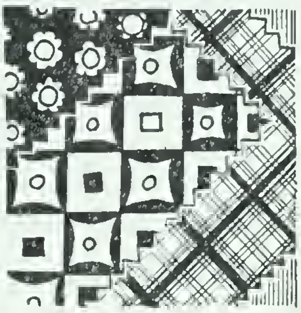
2. *Silk.* Silk is a naturally lustrous fiber, but the gum must be removed before the luster becomes apparent.

3. *Linen.* The luster of the flax fiber is apparent at all times. This

characteristic proves helpful when identification of the fiber is necessary.

4. *Cotton.* In its natural state, cotton fiber has no luster.

5. *Wool.* Wool fiber has no luster because of its serrated surface. Some yarns that belong to the wool group, however, show some degree of luster; these yarns are the hair fibers, such as mohair, vicuna, camel's hair, alpaca, and cashmere.



**Affinity of Fibers for Dyes.** The readiness with which a fiber absorbs and retains dye affects the appearance and serviceability of a fabric. Affinity for dyes is usually determined by the porosity of a fiber.

The sequence of fibers according to affinity for dyes is as follows:

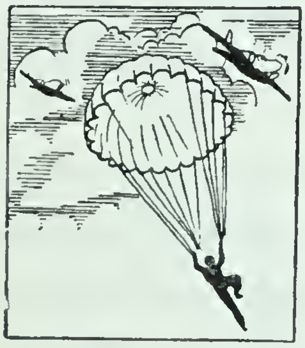
1. *Wool.* Wool has a very high affinity for dyes. Wool fabrics dye well and evenly.

2. *Rayon.* Rayon also reacts favorably to dyes. The dyestuff is absorbed evenly, and the material is consequently dyed successfully. Acetate rayon requires a separate class of dyes.

3. *Silk.* Silk has a good affinity for most dyestuffs.

4. *Cotton.* While cotton does not have a natural affinity for dyes, it is usually treated in a manner that will assure fastness of color. Mercerized cotton, for example, absorbs and retains dyes better than do cottons that have not been so treated.

5. *Linen.* Linen fibers have a poor affinity for dyes. The hard, nonporous surface of the fiber and its natural gum content (pectin) do not allow even penetration of the dyestuff. A more favorable reaction can be induced by removal of the pectin by means of a strong bleaching process, but this process may entail some sacrifice in the durability of the fabric. For this reason, unbleached linens are preferable when extreme whiteness is not a primary consideration.



**Fineness of Fiber Diameter.** A fiber of large diameter or a relatively coarse fiber, of which wool is a typical example, affects the kind of yarn produced. A finer or thinner yarn is more easily made with such fine fibers as silk, rayon, or even cotton.

The sequence of the fibers according to comparative diameter is as follows:

1. *Cuprammonium rayon.* Cuprammonium can be produced as a very fine fiber, and it makes one of the finest yarns in the textile industry.

2. *Silk.* Silk makes a thin yarn because its filament is naturally fine.

3. *Cotton.* As the longest cotton fibers have the smallest diameters, the length of staple determines the fineness of the yarn.

4. *Linen.* The flax fiber is composed of fine enough filaments to permit the production of the fine yarns used for soft linens. In general, however, the flax fiber is relatively coarse; and the greater part of linen yarns are of varying diameters, with characteristic unevenness.

5. *Wool.* The shorter wool fibers have fine diameters. The coarser fibers make heavier yarns.

**Reaction of Fibers to Alkalies and Acids.** In studying textiles, a knowledge of the reaction of the textile fibers to alkalies and acids is important. Alkalies destroy animal fibers; acids, even in a weak solution, destroy vegetable fibers. For example, chemical tests for determining the fiber content of fabrics are made by noting the disintegration of wool and silk when exposed to a strong alkali, and a similar reaction when cotton and linen are exposed to acids.

Good results in the bleaching, finishing, and dyeing processes are dependent on the reaction of the fibers to alkali or acid chemical agents.

Not only is this reaction important in testing and manufacturing; it also closely touches the consumer when the care of fabrics is considered. For example, care must be taken not to expose cotton and linen to perspiration, because perspiration is basically acidic and tends to destroy cotton, linen, and regenerated rayons.

This reaction to alkalies and acids is most important to the consumer when fabrics are washed. As the brown soap ordinarily used for household laundry is a strong alkali, it must not be used for silk or wool fabrics. An example of a mild acid used in the household is acetic acid, better known as vinegar.

*Cotton.* Cotton is destroyed by concentrated inorganic acids—such as hydrochloric, hydrofluoric, sulphuric, and nitric—and is damaged when such acids are in dilute solutions. It is not injured by alkalies even in hot, strong solutions; strong soap may be used for washing

## Summary of Differential Qualities of Fibers

| Characteristic | Cotton | Linen | Wool | Silk | Viscose and Cuprammonium Rayons | Acetate Rayon |
|---|---|---|---|---|---|---|
| Strength | Strong when mercerized | Stronger than cotton | Weakest | Strongest | Materially weakened when wet | Loses about one-third strength when wet |
| Elasticity (resistance to wrinkling) | Not elastic | Least elastic | Most elastic | Good elasticity | Poor; can be made crease-resistant by reducing to short staple | More crease-resistant than regenerated rayon |
| Heat Conductivity (ability to carry off body warmth) | Good conductor; makes a cool fabric | Best conductor; makes the coolest fabric | Nonconductor; makes the warmest fabric | Nonconductor; makes a warm fabric | Good conductor; like cotton and linen; makes a cool fabric | Like silk; nonconductor; makes a warm fabric |
| Absorbency | Absorbent; dries quickly; feels clammy when wet | Very absorbent; dries quickly and produces cooling effect | Most absorbent; will hold much moisture without feeling wet | Very absorbent | Like silk | Absorbs slowly and dries quickly, thus resistant to moisture |
| Reaction to Alkalies (strong soaps) | Not affected | Not affected | Easily harmed | Easily harmed | Like cotton and linen | May be damaged by strong soap, and if extremely high temperature of water is used |
| Resistance to Acids (basis of perspiration) | Easily affected | Easily affected | Not affected | Somewhat weakened | Like cotton and linen | Least affected because of good resistance to moisture |

cotton. Cotton fabrics quickly deteriorate when exposed to perspiration.

*Linen.* The reaction of linen to acids is similar to that of cotton. Although linen is not readily damaged by alkalies, strong soap should not be rubbed on linen fabrics because a strong caustic soap bath turns linen yellowish.

*Wool.* Dilute acids do not injure wool, but concentrated acids destroy it. Wool is quickly destroyed by strong alkalies; it dissolves if completely immersed in a boiling alkali. A neutral or mild soap must be used for washing wool.

*Silk.* The organic acids—acetic, tartaric, stearic, and formic—have little effect on silk. Weak inorganic acids also have little effect, but strong solutions injure silk. A dilute solution of nitric acid produces a bright-yellow color in silk, and this reaction identifies silk from wool when testing. Perspiration causes deterioration in silk fabrics.

Silk is destroyed by strong alkalies; strong soap should be avoided when washing silk. Compared with wool, silk is more resistant to alkalies but less resistant to strong acids.

*Rayon.* Hot dilute solutions or cold concentrated solutions of strong inorganic acids, such as sulphuric, hydrochloric, hydrofluoric, and nitric, destroy rayon. The organic acids, formic and acetic, do not affect viscose or cuprammonium rayon but do disintegrate acetate rayon. Acetate, however, withstands solutions as strong as 28 per cent.

Regenerated rayons are not readily damaged by alkalies, but these rayons are less resistant than cotton or linen. Both viscose and cuprammonium lose tensile strength when exposed to a weak solution of a strong alkali, such as caustic soda. Acetate is more easily affected, especially if water of an extremely high temperature is used.

*Test yourself on this chapter by answering these questions:*

1. How may a knowledge of textiles help the consumer?
2. What is the sequence of development of fiber into cloth?
3. What practical significance does the quality of absorbency have in apparel?
4. Explain how length of staple affects the quality of a fabric.
5. What quality of acetate rayon makes it desirable for winter underwear?

6. What type of rayon would make the best-wearing coat lining? Why?

7. Why is elasticity important in textiles? How may elasticity in textile fabrics be improved?

8. What qualities of linen make it suitable for (*a*) towels and handkerchiefs, (*b*) summer suits, (*c*) draperies, (*d*) summer shoes?

9. What qualities of silk make it suitable for (*a*) women's dresses, (*b*) fishlines, (*c*) neckties, (*d*) hosiery, (*e*) ribbons?

10. Why is cotton used so extensively for infants' wear?

11. What qualities of regenerated rayon make it a poor fiber to use for (*a*) sewing thread, (*b*) stockings, (*c*) winter underwear?

12. What specific qualities do spun-rayon fabrics have that are not found in long-staple rayons?

13. What properties may wool fabric be expected to have? How do they affect the serviceability of wool?

14. How does a napped surface affect the hygienic quality of a fabric?

15. Why does a cotton bathing suit feel cooler than a woolen one?

## Suggested Readings

Dooley, W. H., *Textiles,* Chapter 1.
Dyer, E., *Textile Fabrics,* Chapters 1, 2.
Matthews, J. M., *The Textile Fibers,* Chapter 1.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 1.
Nystrom, P. H., *Textiles,* Chapter 1.
Small, C. P., *How to Know Textiles,* Chapters 1, 2.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 26.

## CHAPTER II

# TESTING FIBERS FOR IDENTIFICATION

Textile fibers are ordinarily classified according to their substance. In other words, cotton and linen are called vegetable fibers because they are derived from plants; wool and silk are called animal fibers because they are derived from sheep and silkworms respectively. Rayon may be said to come under the vegetable classification because, although rayon is a man-made fiber, it is made from cellulose, an important ingredient of all plant life.

The value of classifying fibers according to substance is evident in many textile operations. Its immediate application is indicated in various physical and chemical tests for identification purposes: (1) testing by microscope, (2) the feeling test, (3) the burning test, (4) the breaking test, (5) chemical tests, (6) nontechnical tests for distinguishing linen from cotton.

**Limitation of Tests.** No single test, other than by microscope, can be depended on to give at all times immediate recognition of every fiber; limitations will be encountered in all the tests. In practice, therefore, identification tests are used in combination. Again certain tests cannot be made freely or easily in the retail store by the consumer at the time of purchase. At that time, the consumer is forced to make use of what might be called nontechnical tests. These are inadequate, yet they convey a certain amount of information if they have been used frequently enough to insure correct observations.

**Testing by Microscope.** Identification by microscope is the most reliable test that can be used to distinguish the fibers. Such identification has already been used in the preceding chapter to introduce the major fibers and to describe their essential qualities. Knowing what the fibers look like under the microscope helps the consumer to understand other identification tests.

It has already been pointed out that certain manufacturing and finishing processes, such as mercerizing and delustering, affect the appearance of a fiber under the microscope. In addition, a dark-colored fabric cannot be identified under the microscope until the dyestuff is removed; the light that is necessary for identification cannot pass through a dark fabric. The dyestuff must be removed, or "stripped," by the use of a bleaching chemical. The choice of the stripping chemical is determined by the composition of the fabric. If the fabric is of vegetable substance, its color can be removed by chlorine water or by sodium hydrosulphite (3 per cent solution, boiling); if of animal substance, a ½ per cent solution of caustic soda will remove the dye.

**Feeling Test.** The feeling test requires skilled perception if the test is to be of any value to the consumer when on a shopping tour. Skilled perception is acquired only after handling many different fabrics over a period of time.

To understand what is meant by "to feel" a fabric, place the finger on a sample of wool. The heat generated by the finger remains in the area because wool is a nonconductor of heat. Consequently, wool fabric "feels warm to the touch." If the finger is placed on a sample that is composed of the vegetable fibers—that is, cotton, linen, or even regenerated rayon—the heat of the finger passes off because such fibers are conductors of heat. Therefore, the fabrics "feel cool to the touch."

Identification of the major fibers by the feeling test may be summarized as follows:

*Cotton.* Cotton is cool to the touch and feels soft and inelastic.

*Linen.* Linen is cold and smooth and has a leathery feel.

*Wool.* Wool is warm to the touch and feels elastic and springy.

*Silk.* Silk feels warm, smooth, and elastic.

*Rayon.* Rayon has the smooth feeling of silk, but it also has a slippery quality because of the inelasticity of the fiber.

*Limitation of the Feeling Test.* Spun rayon cannot be detected by the feeling test alone, as spun rayon can be made to look and feel like cotton, wool, or linen. The rough texture of crepe rayons also limits this test.

**Burning Test.** To recognize the composition of fabrics by the burning test, the tester must note three things: (1) how the yarn ignites when flame is applied; (2) the condition of the burned portion; (3) the odor produced by the burning.

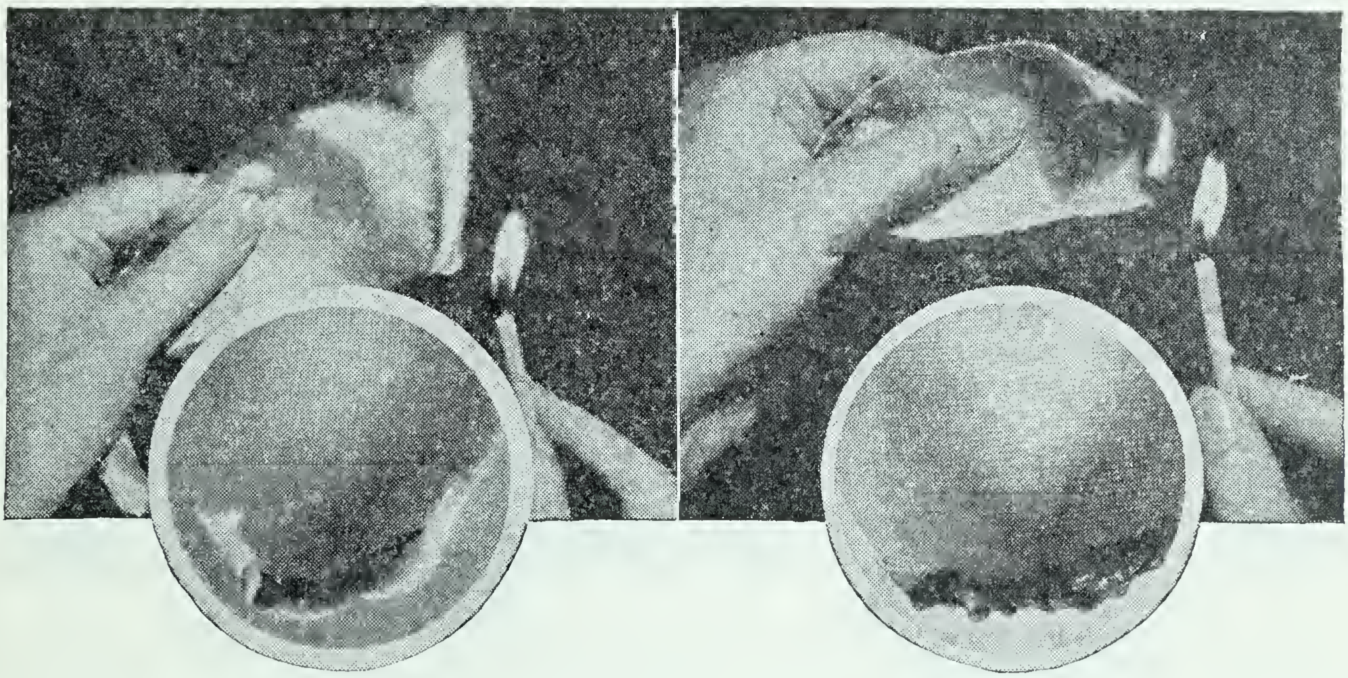
If both the lengthwise and the crosswise yarns in a fabric are known to be of the same substance, the sample may be tested as a whole. Different kinds of yarn, however, are sometimes used in a fabric. When the presence of yarns of different substances is suspected, the length-

SUMMARY OF THE BURNING TEST FOR MAJOR FIBERS

| Yarn | Flame | Odor | Ash |
|---|---|---|---|
| COTTON | Large yellow flame; burns quickly | Like burned paper | Light, feathery grayish ash; black ash denotes mercerized cotton |
| LINEN | Like cotton; sometimes slower if yarns are heavier | Like burned paper | Like cotton; sometimes heavier if yarn is thicker |
| WOOL | Small, slow flickering flame; sizzles and curls; ceases flaming when withdrawn from flame | Strong animal stench like burning feathers or hair | Crisp, dark ash; irregular shape that can be crushed easily |
| SILK (Pure dye) | Burns slowly; ceases flaming when withdrawn from flame | Gives off an animal odor, but less pronounced than wool | Round, crisp, shiny black beads that can be easily crushed with the fingers |
| SILK (Weighted) | No flame; burned part becomes incandescent and chars | Same as pure silk | Screenlike skeleton of original sample |
| REGENERATED RAYONS | Ignites quickly like cotton, sometimes faster than cotton | Like burned paper | Like cotton |
| ACETATE RAYON | Flames quickly; material puckers, sputters, melts; drips like tar | Acid, like vinegar | Brittle black ash, difficult to crush between the fingers; unlike ash of any other fibers |

wise yarns should be separated from the crosswise yarns, and each set should be tested separately.

To avoid burning the fingers, a candle flame rather than a lighted match should be used when the burning test is made. Also, the sulphur odor from the match causes confusion when testing for odor. Additional precaution should be taken to protect the fingers from the flame by holding the sample with tweezers or any metal holder.

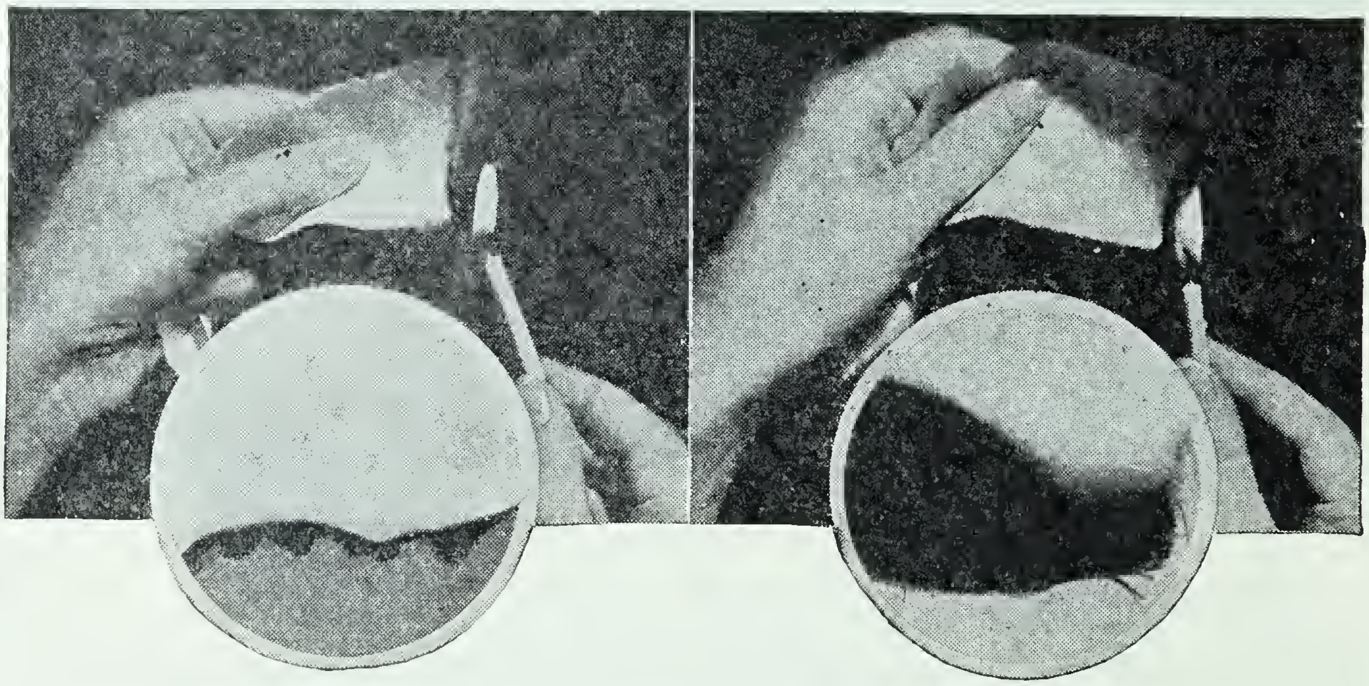


*Left:* Acetate rayon blazes as it burns. The fabric puckers, curls, and fuses into an irregular black residue that hardens when cooled.
*Right:* Wool burns slowly with a small, flickering flame. The fabric sizzles and curls. The ash is black, irregular, and crisp.

*Cotton.* Cotton yarn blazes quickly when it comes in contact with the flame because the cellulose ingredient is highly inflammable. The ash is light and feathery and has a vegetable odor similar to that of burned paper; mercerized cotton produces a black ash. Because cotton is highly inflammable, the prudent housewife will not use cotton where its proximity to flame becomes a fire hazard; for example, pot holders should be made of wool, never of cotton.

*Linen.* Linen, when burned, produces an ash similar to cotton ash because both fabrics are of vegetable substance. Linen ash is also light and feathery and has the odor of burned paper. Linen as a fabric, however, burns somewhat more slowly than cotton because linen yarns are heavier than cotton yarns. The pace of burning, however, is not sufficiently different to aid in distinguishing linen from cotton.

*Wool.* Wool is slow to ignite and has a characteristic small, slow, flickering flame that sizzles and curls. It can be extinguished easily, as the fabric ceases flaming when the fire is withdrawn. Wool ash is dark and crisp. It falls into an irregular shape and can be crushed easily. The ash has a strong animal odor resembling burning feathers or hair. This odor indicates the presence of an animal substance or of a fiber obtained from an animal. The offensive odor characteristic of burned wool is due to the sulphur ingredient.



*Left:* Pure-dye silk burns with a small flame that soon dies, leaving an ash in the form of small, brittle shiny-black balls along the edge of the fabric.
*Right:* Weighted silk burns without showing a visible flame. It chars and leaves a coherent ash, a skeleton of the original fabric.

*Silk.* Pure silk also burns slowly and ceases flaming when the fire is withdrawn. The ash of silk appears in the form of round, crisp, shiny black beads that, like the ash of wool, can be crushed easily with the fingers. The ash gives forth an animal odor, but one that is less pronounced than that of wool as silk does not contain sulphur.

In textile manufacturing, additional body is given to silk fabrics by weighting them with metallic fillers. Weighted silk burns without showing a visible flame. The burned part becomes incandescent; it chars and gradually smolders away, leaving a coherent ash that is a screenlike skeleton of the original fabric. The odor of the ash of weighted silk, however, is similar to that of pure silk.

*Rayon.* The burning test reveals different reactions in the regenerated and the acetate types of rayon because of differences in the manufacturing process and in the chemicals used. Like cotton, regenerated rayon ignites quickly. It burns with a bright-yellow flame, sometimes more rapidly than cotton because regenerated rayon is essentially a purified cellulose. The ash of regenerated rayon has the same odor as that of cotton and linen ash and is similarly light and feathery.

*Acetate.* Acetate blazes as it burns. The edge of the fabric puckers and curls as the material fuses and melts into a hard mass. Acetate sputters and drips like tar. The ash of acetate is hard and brittle, and is difficult to crush between the fingers; it is unlike the ash of any other fiber. Because of the acetic acid that is used in the manufacture of acetate, the ash has an acid odor similar to that of vinegar.

*Limitation of the Burning Test.* As cotton, linen, and regenerated rayon show a large yellow flame, rapid burning, and a light, feathery ash that gives off an odor similar to that of burned paper, the burning test is of no value in distinguishing these three fibers from one another. But this test is important in distinguishing cotton, linen, and regenerated rayon from the other fibers.

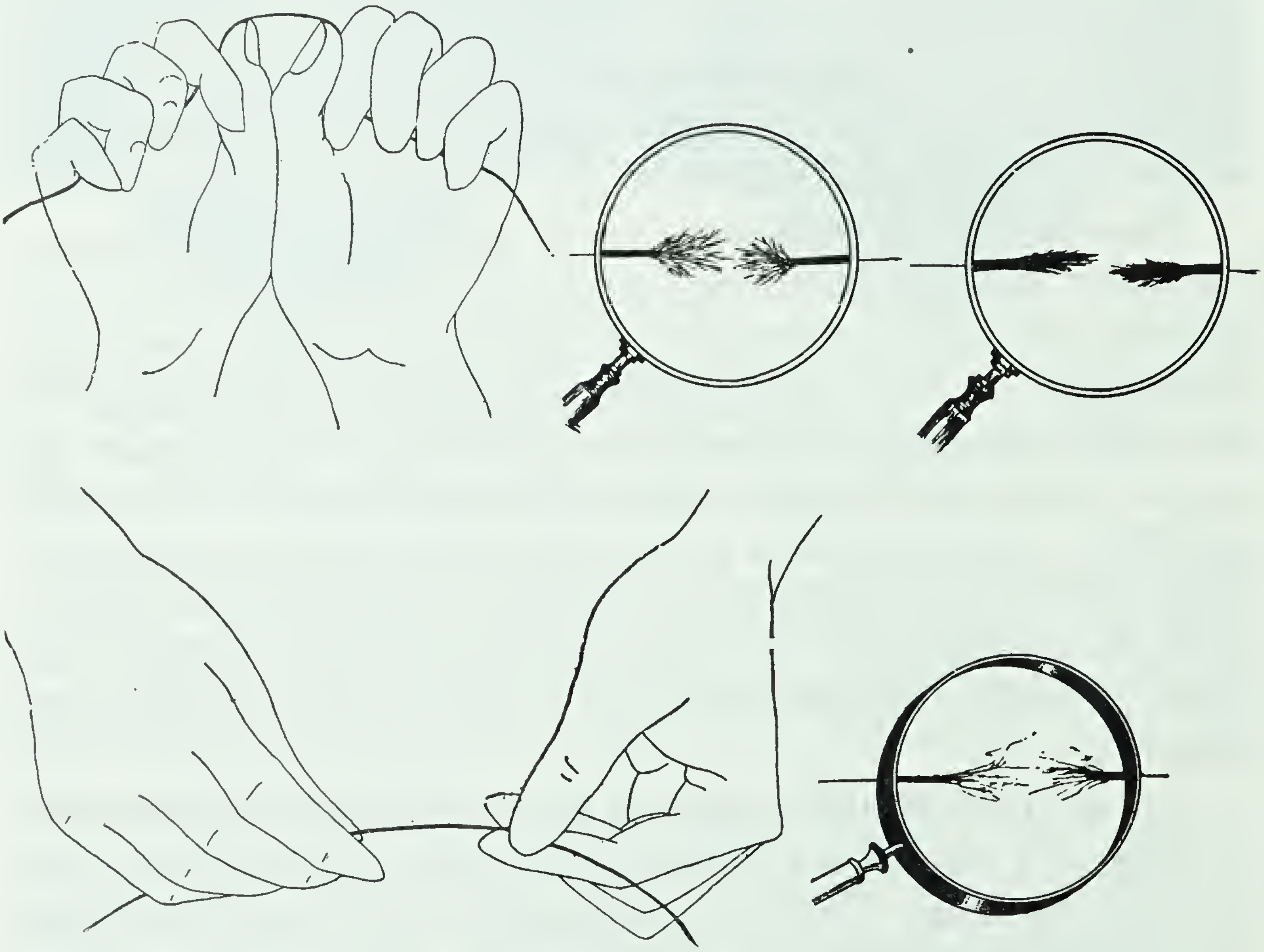
**Breaking Test.** The breaking test is nontechnical, yet it affords a convenient means of identifying fabrics. Recognition of a yarn by the breaking test requires observation of the fiber ends when the yarn is broken apart. A piece of yarn about 12 inches long is required for this test. The yarn must be untwisted very gently in order to restore the natural formation of the fiber before twist was inserted by the spinning operation. Sometimes two or more strands are combined to make up a single yarn. In such cases, the yarn must be untwisted gently until a single strand is obtained. Care must also be used when pulling a yarn apart; otherwise, the broken fiber ends will not take their characteristic pattern.

*Cotton.* Because cotton yarns are made from short-staple fiber, the breaking of a cotton yarn will show fiber ends that are short, even, fuzzy, and brushlike. There is a characteristic curl to the ends, caused by the natural twist of the fiber. The inelasticity of cotton yarn causes the yarn to snap when pulled apart.

*Linen.* When it is suspected that a yarn is composed of linen fiber, a long piece of yarn is necessary for testing because long staple may be anticipated. If a break does not occur readily when the yarn is untwisted and gently pulled apart, the span must be increased in order to exert tension on a longer staple. Untwisting should be continued along the span and the yarn again pulled gently. If necessary, the span should be increased again. The breaking pattern of a linen yarn shows long, straight, lustrous fiber ends that are pointed and uneven at the tips. The fiber ends never curl; instead, they point outward with marked stiffness that indicates the inelasticity of the linen fiber.

*Wool.* A wool yarn has a characteristic fuzzy surface. When the yarn is pulled gently for the breaking test, it stretches easily because of its remarkable elasticity. The breaking pattern shows fiber ends that are wavy and spiral in shape.

*Silk.* A silk yarn stretches easily when pulled because silk ranks next to wool in elasticity. Because of its strength, the silk yarn stretches



To examine the breaking pattern of cotton or rayon yarn, untwist the yarn and tear it apart, using both thumbs. Rayon yarn will show lustrous, inelastic filaments. Cotton yarn will show brushlike ends that are short, even, and fuzzy. To examine the breaking pattern of linen yarn, untwist the yarn and tear it apart, using the index fingers as well as the thumbs. Linen yarn will break unevenly, showing long, pointed ends that are inelastic and lustrous.

a considerable degree, breaking apart finally with a snap, but only after it has exceeded its limit of stretching. The fiber ends, when broken, appear fine and lustrous.

*Rayon.* If tension is exerted on a dry rayon yarn, the yarn appears to be comparatively strong, though inelastic, and does not break easily. If the yarn is moistened with the tongue, a slight pull breaks the yarn. When broken, the fiber ends create a pattern similar to that of a tree with numerous stiff branches. This effect is produced by the explosive-like bursting of the separate filaments.

Rayon's loss of strength when wet can be readily detected by the moisture test. Moisten rayon yarn slightly, as illustrated, and then pull both ends.

*Limitation of the Breaking Test.* One limitation of the breaking test is indicated in testing spun rayon. As spun rayon can easily simulate wool, linen, or even cotton, the breaking pattern of this rayon is similar to the characteristic pattern of wool or of linen. When the burning test is used as an additional means of identification, the rayon yarn that resembles wool reveals the lack of animal odor that is characteristic of wool. Rayon yarn that resembles linen can be detected by exerting tension on the yarn after moistening it with the tongue. The characteristic loss of strength that rayon shows when wet is evident.

**Chemical Tests.** In addition to the microscope, chemical tests provide positive means of identifying fibers. But chemical tests are not intended for the general consumer. Their value is demonstrated, however, by the fact that some retail stores have their own laboratories for testing fabrics.

*To Distinguish Animal from Vegetable Fibers with an Alkali.* As strong alkalies destroy animal substances, a 5 per cent solution of lye in water (½ teaspoon of lye in a glass of water) can be used to elim-

Chemical testing of fibers.

inate wool and silk fibers from a sample that contains a mixture of fibers. The action of this chemical (also known as caustic soda or sodium hydroxide) is hastened by boiling the solution before the sample is immersed. The wool and silk fibers will be completely dissolved. The vegetable fibers will not be affected. Another test is necessary to identify those fibers.

*To Distinguish Vegetable from Animal Fibers with an Acid.* As dilute acids destroy vegetable fibers, a 2 per cent solution of sulphuric acid may be used to distinguish vegetable from animal fibers. A drop of the solution is placed on a sample of the fabric, which is then placed between two blotters and pressed with a hot iron. The spotted area will become charred if the fabric is cotton, linen, or regenerated rayon.

*To Distinguish Silk from Wool.* If the fibers in a sample are known

RESULTS OF SIMPLE CHEMICAL TESTS

| Fabric | Alkali 5% Solution (Boiling) | Hydrochloric Acid (Cold) Concentrated | Sulphuric Acid 2% (Hot) | Acetone |
|---|---|---|---|---|
| WOOL | Destroyed | Swells | ...... | ...... |
| SILK | Destroyed | Destroyed | ...... | ...... |
| COTTON | ...... | ...... | Charred | ...... |
| LINEN | ...... | ...... | Charred | ...... |
| VISCOSE AND CUPRAMMONIUM | ...... | ...... | Charred | ...... |
| ACETATE | ...... | ...... | ...... | Destroyed |

to consist of silk and wool, and identification of each is desired, the use of concentrated hydrochloric acid (cold) will dissolve the silk and cause the wool fiber to swell.

*To Distinguish Linen from Cotton.* Before any chemical test is made to distinguish linen from cotton, all surface dressings should be removed from the samples by boiling them for a few minutes in a solution of dilute sodium hydroxide, about ½ per cent. Then any of the following tests can be made.

Immersing cotton and linen samples in a 1 per cent solution of fuchsin in alcohol produces a rose-red color in both samples. After the samples have been washed and then immersed in ammonia, linen retains the red coloration, but cotton does not. This test is sometimes made with a 1 per cent solution of magenta, a red dyestuff.

If samples of cotton and linen are immersed in an alcoholic solution of rosalic acid for a few minutes, then washed and immersed quickly in strong caustic soda and washed again, linen turns rose red, and cotton appears only slightly colored.

Cotton fibers are weakened more than linen fibers if samples are immersed in concentrated sulphuric acid for two minutes. After the samples are rinsed and immersed in weak ammonia, the cotton fibers dissolve, leaving the linen fibers unaffected.

When cotton and linen samples are immersed in a solution of iodine and zinc chloride (Herzberg's stain), cotton is stained reddish purple, and linen is stained blue to purple.

When samples are immersed in a caustic soda solution, cotton remains white and linen turns yellowish.

*To Distinguish Acetate Rayon from Other Fibers.* If a sample of acetate rayon is immersed in acetone (a chemical used in nail-polish removers), the acetate fibers are completely dissolved; other fibers are not affected.

A test to distinguish acetate rayon from regenerated rayon, when both types are known to be used in a fabric, is to immerse the sample in a 50 per cent solution of acetic acid. The acetate rayon dissolves; regenerated rayon is not affected.

*To Distinguish Viscose, Cuprammonium, and Acetate Rayons.* A solution containing equal parts of concentrated sulphuric acid and iodine (crystals) may be used to distinguish each of the different rayons. When samples are immersed in this solution, a dark-blue coloration indicates viscose; a light-blue coloration indicates cuprammonium; a yellow coloration indicates acetate.

**Nontechnical Tests for Distinguishing Linen from Cotton.** The identification of linen and cotton fabrics has always been of special interest to the analytical consumer. Because cotton can be made to simulate linen, additional nontechnical tests for distinguishing linen from cotton are evaluated here. Some of these tests are adequate; others are not recommended because finishing substances that are commonly used in the manufacturing process interfere with the expected reaction.

*Squeezing Test.* A simple method of distinguishing linen from cotton is the pulling of a yarn through two tightly compressed fingertips. If the yarn emerges stiff and straight, it is linen; if the yarn is limp and drooping, it is cotton.

*Curl Test.* If the end of a single filament turns in a clockwise direction when squeezed between the moistened thumb and finger, the fabric is linen. If the tip turns counterclockwise, the fabric is cotton.

*Tearing Test.* Linen fabrics do not tear readily, but they do tend to slip apart when subjected to strain. A sample may be identified as cotton if it tears readily with a characteristic shrill sound.

*Reaction to Oil.* If lightweight oil or glycerine is dropped on a sample of linen, a translucent area appears on the fabric; if dropped on cotton, the area is opaque.

*Ink Test.* If a drop of ink is placed on a linen fabric, the ink spreads evenly in a circular form. In contrast, a drop of ink on a cotton fabric tends to spread outward with a fading density toward the outer edge, making a slightly irregular outer rim, more oval than circular. The ink test, however, is not considered reliable because finishing substances may interfere with the reaction just described.

*Moisture Test.* A common practice is to attempt to identify linen by noting the pace of absorption when a drop of saliva is placed on the undersurface of the fabric. As linen absorbs water quickly, it is believed that this test will identify the linen fiber. But finishing substances prevalent in the dressing of linens interfere with this test; therefore it is not recommended. Also, sheer cotton fabrics absorb a drop of saliva even more quickly than any fine linen.

*Test yourself on this chapter by answering these questions:*

1. Why is the classification of fibers according to their substance important for identification purposes?
2. List the advantages and the limitations of the burning test when the test is used to differentiate cotton, linen, silk, wool, acetate, rayon, and regenerated rayon.
3. Describe three tests used to differentiate cotton and linen.
4. Describe the chemical test used to differentiate acetate, viscose, and cuprammonium rayons.
5. Describe the breaking test as applied to cotton, linen, wool, silk.
6. Describe the differences between cotton and wool in the burning test.
7. Assume that you have samples of linen, cotton, silk, and wool materials, all unmarked. What chemical processes would you use to distinguish the animal fibers from the vegetable fibers? To distinguish cotton from linen?
8. Why is spun rayon difficult to identify by the feeling test or the breaking test?
9. What two positive tests permit identification of the three rayons?

10. What are the three tests by which silk may be differentiated from rayon?

11. Compare the effect of burning on acetate and on regenerated rayon in regard to flame, odor, and ash.

12. Compare the results of the breaking test on viscose rayon and on linen yarn.

13. In selecting yard goods for a skirt, what tests can be used to determine whether the material is wool or cotton or a mixture?

14. Why would you choose a woolen blanket instead of a cotton blanket to put out a flame?

15. A consumer used the moisture test to determine whether sheets were linen or cotton. Why could the moisture test fail? What other tests would you suggest? Explain fully.

## Suggested Readings

Bray, H. A., *Textile Fibers, Yarns, and Fabrics,* Part 4.
Dooley, W. H., *Textiles,* Chapter 33.
Dyer, E., *Textile Fabrics,* Chapter 3.
Evans, M., and McGowan, E. B., *A Guide to Textiles,* pp. 155–172.
Matthews, J. M., *The Textile Fibers,* Chapters 4, 5, 27.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 9.
National Retail Dry Goods Association, *Tests to Identify Textile Fibers.*
Nystrom, P. H., *Textiles,* Chapter 24.
Wingate, I. B., *Textile Fabrics,* Chapter 3.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 27.

## CHAPTER III

# FIBER TO YARN: SPINNING

The formation of yarn becomes possible when fibers have surfaces that are capable of cohesiveness. This quality is exemplified by the serrations of the wool fiber, the convolutions of the cotton fiber, and the roughness of the flax fiber. Elasticity or flexibility permits the fibers to be twisted around one another.

Primitive man discovered that a succession of fibers could be twisted into a continuous yarn. This was probably accomplished slowly and laboriously at first, but the greater strength thus produced and the many uses soon found for articles made from continuous yarns led to the invention of hand implements to aid and improve the process of twisting and spinning. Many such implements and methods are still used by the more primitive peoples in various parts of the world as well as by persons who are interested in reviving artistic handicraft.

At the same time that a method of twisting fibers into yarn was discovered, it was necessary to invent simple methods of disentangling, separating, and arranging the fibers according to their length, other than by just using the fingers. Thus, crude methods of carding separated the fibers according to their length of staple. Uniformity of staple gives yarns a required evenness and improves the quality of the yarn.

**Development of Fiber into Yarn.** The value and character of a yarn are determined by (1) the kind and quality of the fiber; (2) the amount of processing necessary to produce fineness; (3) the amount of twist, which increases tensile strength in the finished yarn. The purpose of the yarn must be anticipated, as this determines the number and kind of manufacturing operations.

The development of fiber into yarn, when stated in terms of basic manufacturing processes, is as follows: carding, combing, drawing out, twisting, and winding. As the raw fiber passes through these processes, it is successively called *lap, sliver, roving,* and finally *yarn.* The manu-

*Left:* Spinning with hand-supported spindle.

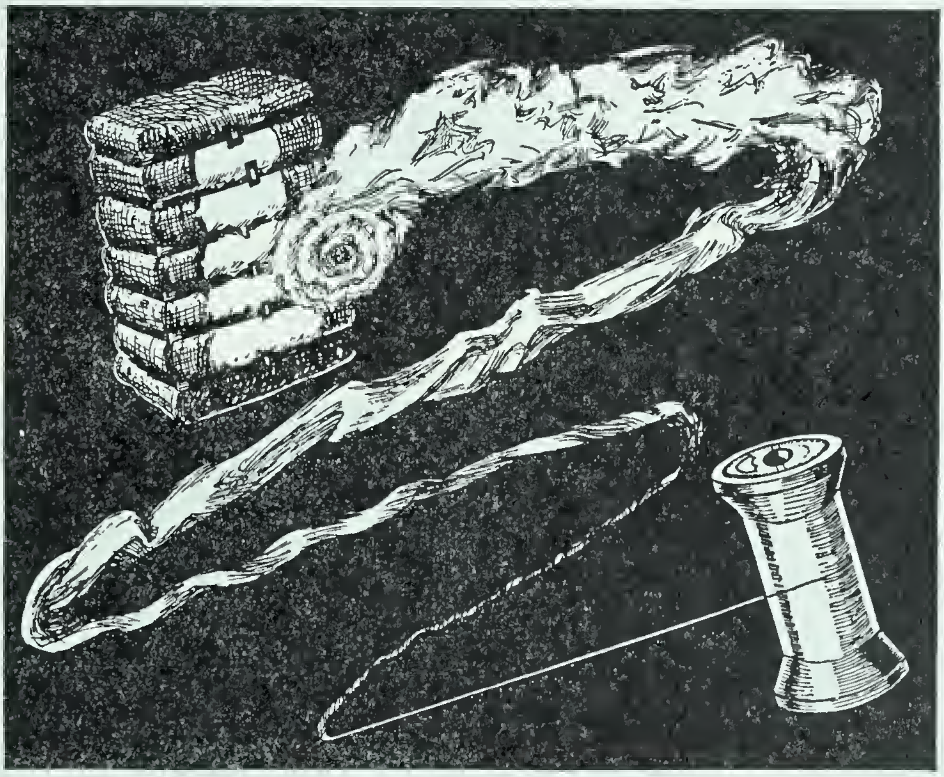
*Lower left:* Hand spinning with distaff and suspended spindle.

*Lower right:* Spinning cotton on a Saxony wheel.

facturing operations in which these stages occur may be summarized as follows:

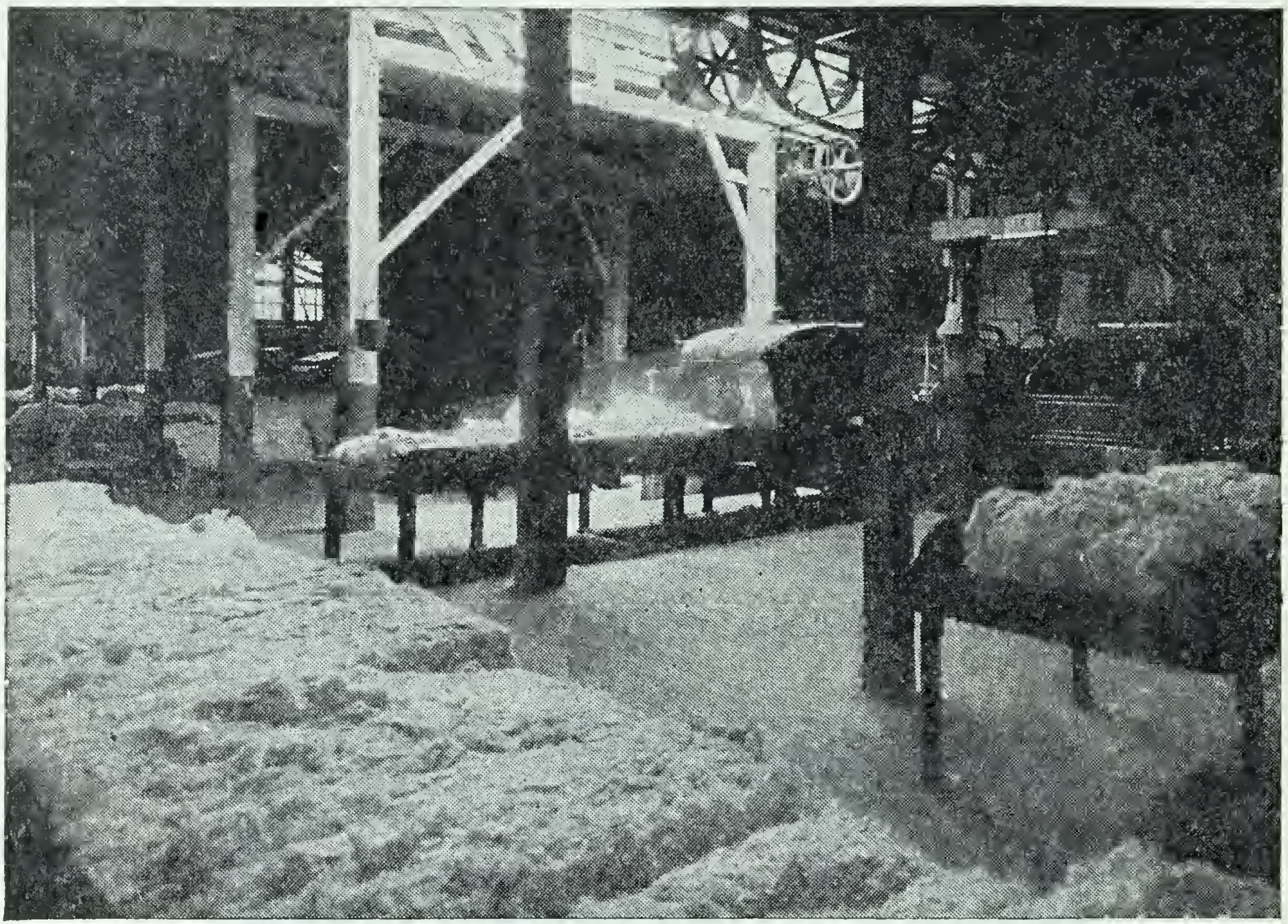
1. Lap to card sliver by the carding process.
2. Card sliver to comb sliver by the combing process (if the fiber is combed).
3. Sliver to roving by the drawing-out process.
4. Roving to yarn by the twisting process.
5. Reeled on bobbins, spools, or cones by the winding process.

Because the production of cotton yarn lends itself to a simple description of the manufacturing operations that make fiber into yarn, cotton fiber has been selected here to illustrate the spinning process. It must be remembered, however, that all other raw fibers pass through similar spinning operations, although, of course, there are differences that will be explained in the chapters dealing with the various fibers.

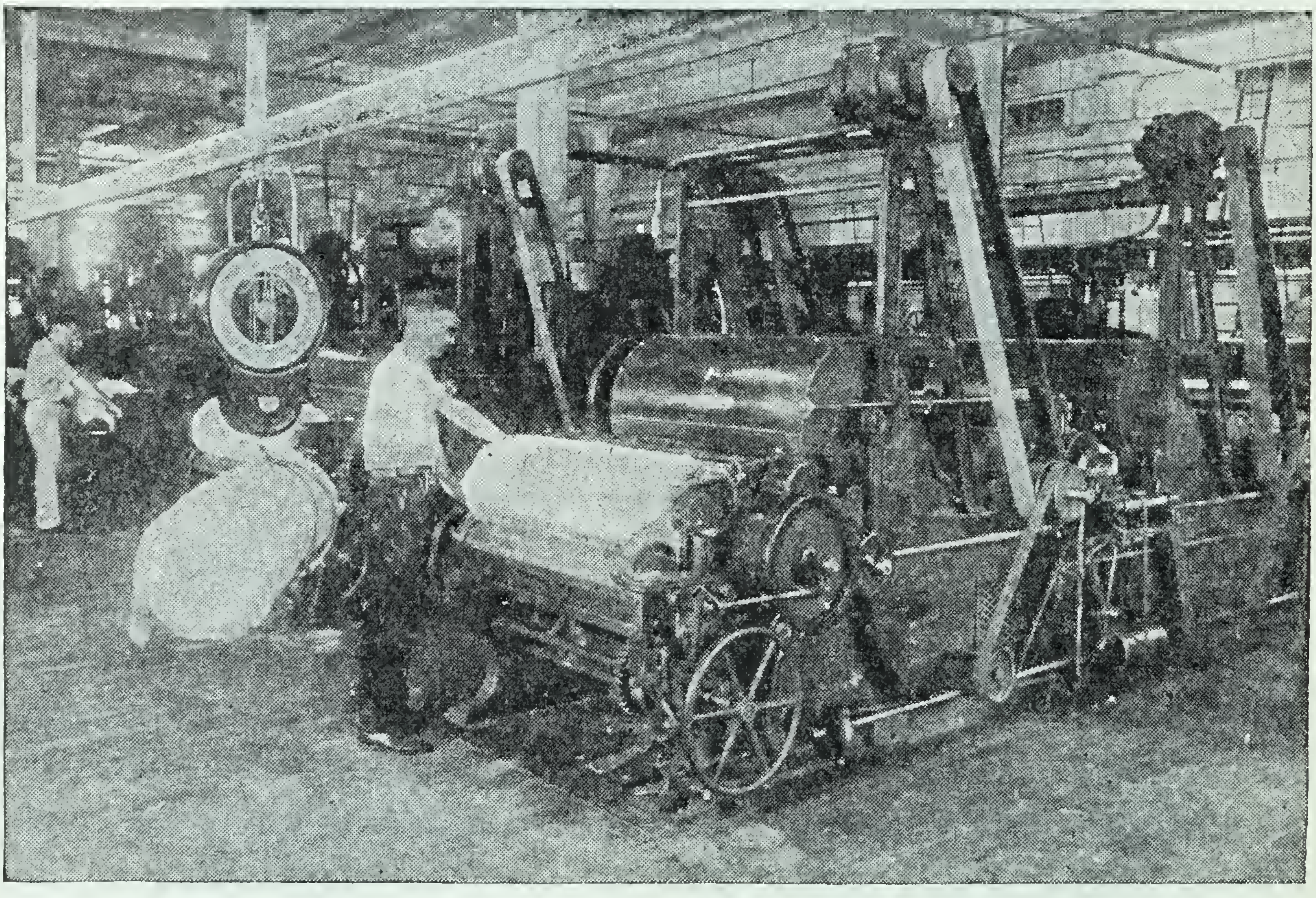


A tangled bunch of cotton fiber is carded into orderly arrangement, drawn out, condensed to a ropelike sliver, then further condensed and twisted into yarn.

**Opening.** When bales of cotton are opened at the mill, the compressed masses of raw cotton fiber are loosened and exposed to the atmosphere. Variation in the raw material is eliminated by mixing together parts of several bales and feeding the material into the open-



In the opener room, cotton from different bales is blended to give a proper mix. The opening machines clean the cotton of leaves, stems, and dirt, and fluff it.



**In the cotton picker, cotton fluff** goes through another cleaning process, and the raw stock is changed to lap—a broad feltlike sheet.

ing machines. This blending of the raw material results in greater uniformity. Hard lumps in the fibers are loosened, and the heavier impurities—such as dirt, leaves, burs, and any remaining seeds—are removed by three machines known as pickers: breaker, intermediate, and finisher. These machines clean and form the cotton into rolls, or laps, that resemble cotton batting; the rolls are 40 inches wide, 1 inch thick, and weigh about 40 pounds each.

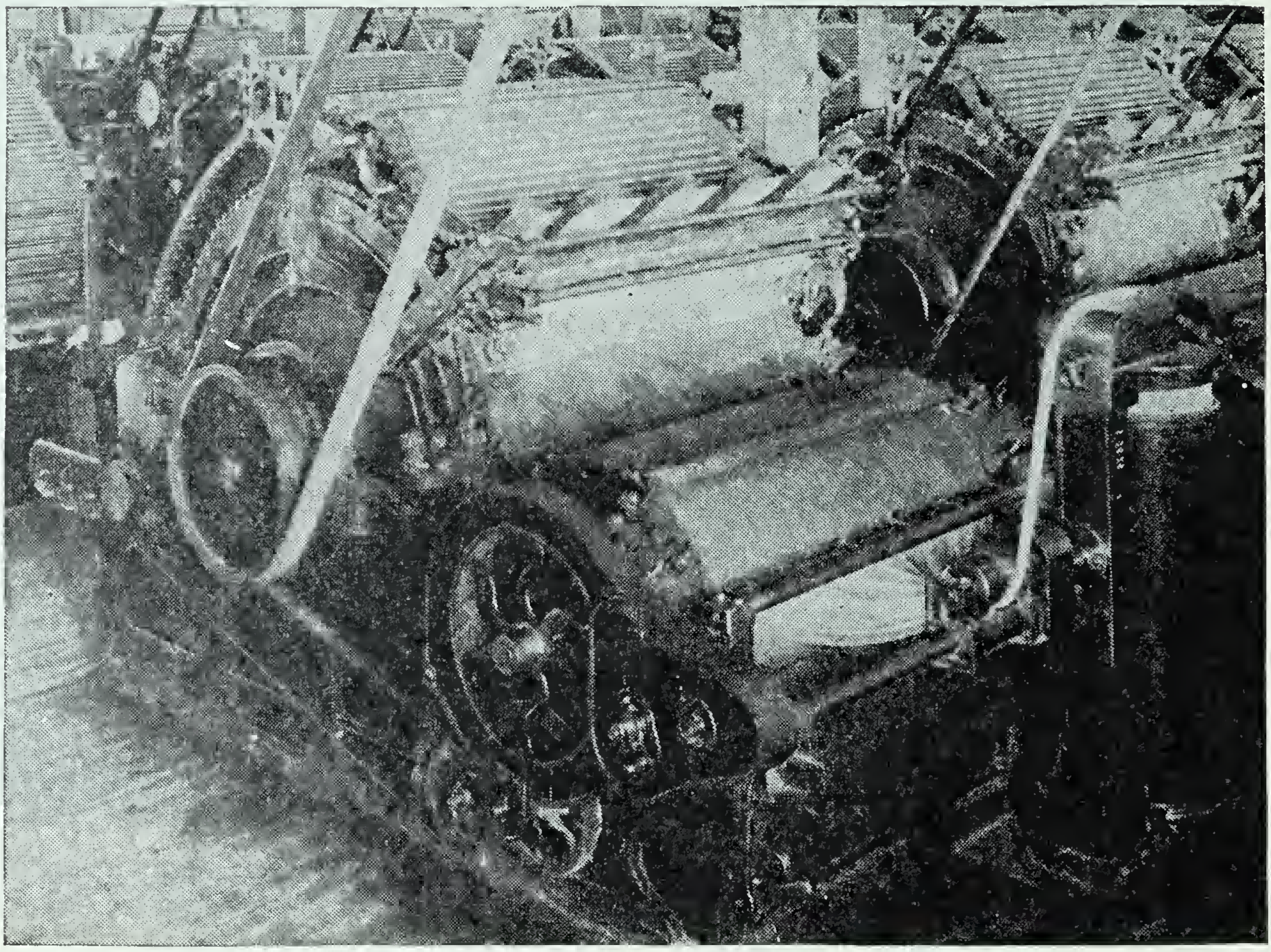
**Carding.** In the lap stage, the fibers are still in a tangled condition, containing waste material. Before this raw stock can be made into yarn, these impurities must be removed, and the fibers must be straightened. Such straightening or smoothing is necessary for all natural fibers; otherwise, it would be impossible to produce fine yarns from what is originally a tangled mass. This initial process of arranging the fibers in a parallel fashion is known as *carding.* The work is done on a carding machine, where the lap is unrolled and drawn on a revolving cylinder that is covered with very fine hooks or wire brushes. On top of this cylinder there is a moving belt, also covered with wire brushes.

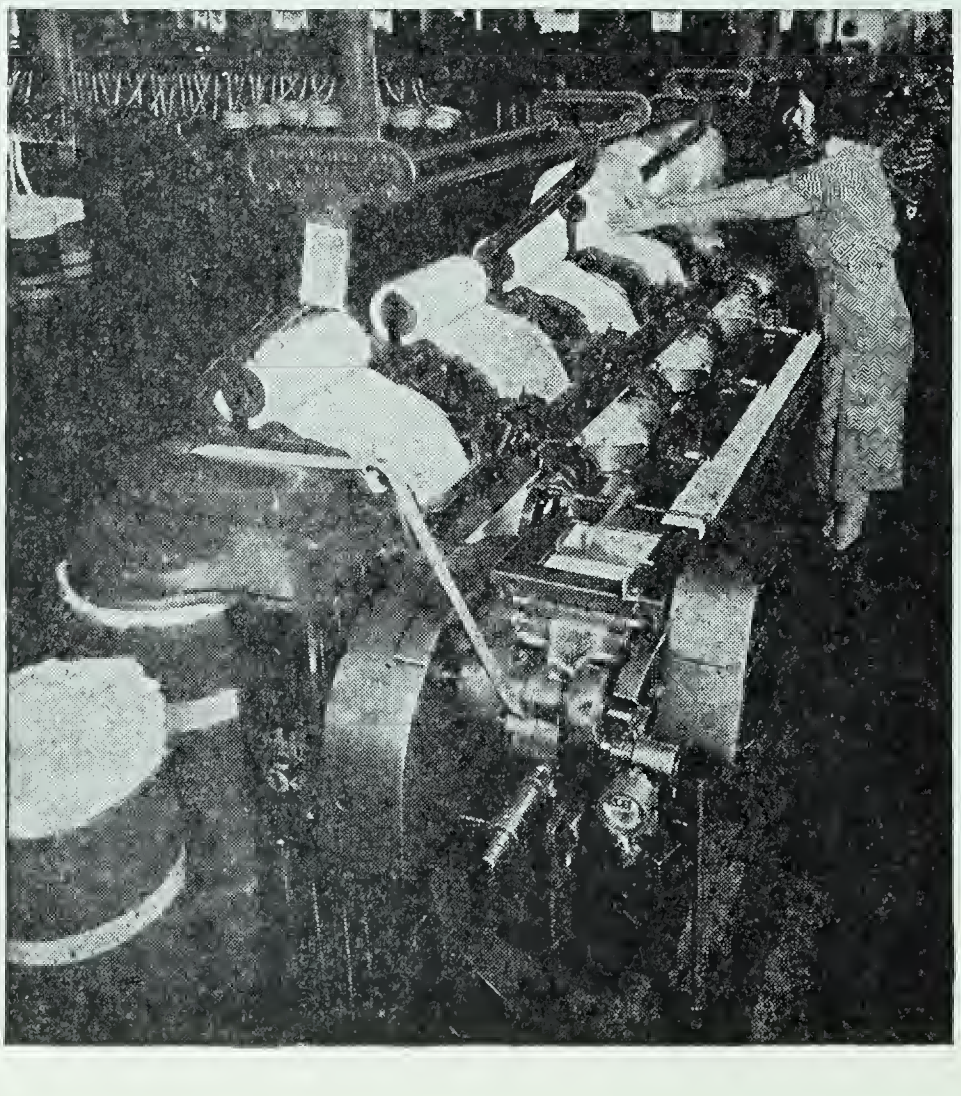
The cylinder pulls the fibers in one direction, disentangles them, and arranges them parallel in the form of a thin film. This film is drawn through a funnel-shaped device that molds the film into a round, ropelike mass called *card sliver,* about the thickness of a broomstick.

Card sliver produces yarns whose serviceability is good enough for ordinary purposes. These yarns are identified as *carded yarns* or *carded cottons* and are used for inexpensive cotton fabrics.

**Combing.** When the fiber is intended for fine yarns, the sliver is put through an additional straightening called *combing.* In this operation, fine-toothed combs continue the process of straightening the fibers until they are arranged with such a high degree of parallelism that the short fibers, called *noils,* are combed out and completely separated from the longer fibers.

The combing process forms a *comb sliver* made of the longest fibers, which, in turn, produce a smoother and more even yarn. This operation eliminates as much as 25 per cent of the original card sliver; thus, almost one-fourth of the raw cotton becomes waste. Therefore, the combing process is identified with consumers' goods of better quality.

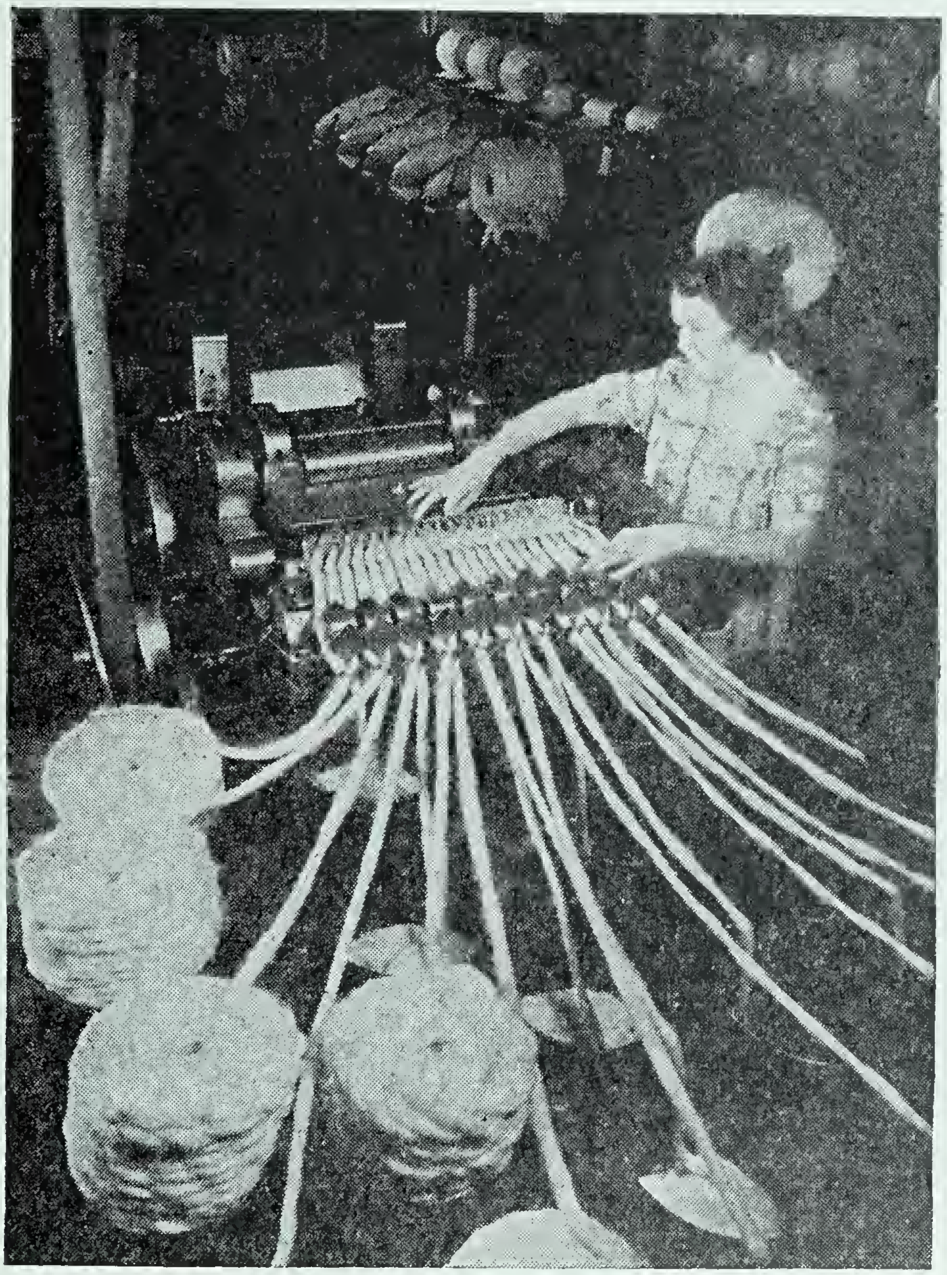




*Above:* The delivery end of the carding machine shows cotton lap being carried around a cylinder. In this process the lap is drawn out and paralleled by means of a dragging action between the top needles and those on the cylinder. Short staple is eliminated, and the filmy sheet of long-staple cotton that remains is formed into a sliver, the ropelike streamer shown at the right.

*Left:* The combing operation removes short fibers and further straightens and parallels the long fibers.

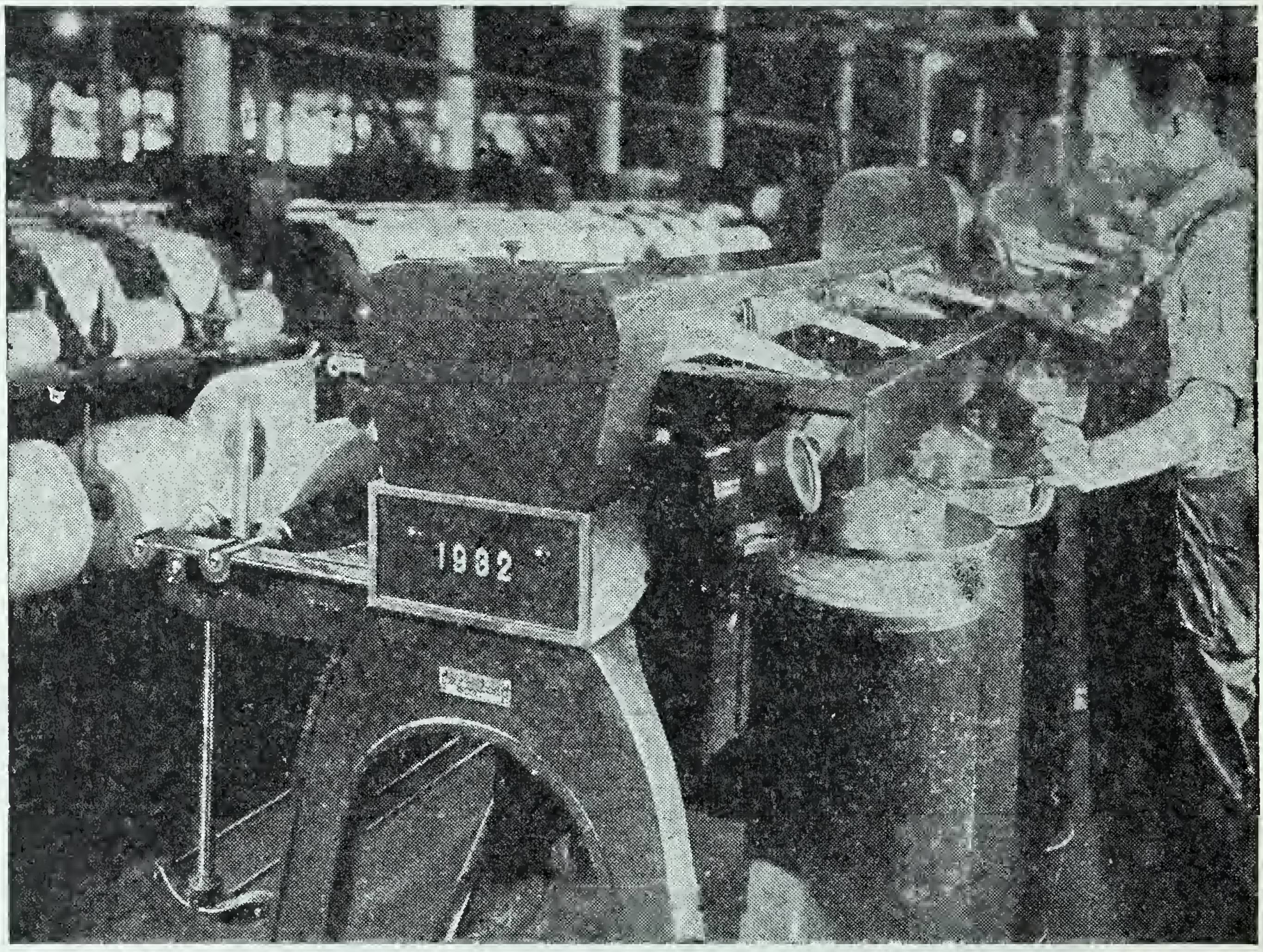
It will be remembered that long-staple yarns produce stronger, smoother, and more serviceable fabrics. Quality cotton goods carry labels indicating that they are made from combed yarns or combed cottons.



After carding, several slivers are combined and drawn out into one sliver lighter in weight than any of the original. The processes of doubling and drawing out assure uniformity in the finished yarn.

**Drawing Out.** After carding (or combing in the case of better-grade yarns), several slivers are combined and put through drawing frames for continued condensation of the cotton stock to a smaller diameter. The combining of several slivers for the drawing-out process eliminates irregularities that would cause too much variation if the slivers were put through singly.

The drawing frame has several pairs of rollers, each set of which revolves at a progressively faster speed. After several stages of drawing out, the condensed sliver is taken to the slubber, where rollers similar to those in the drawing frame draw out the cotton further. Here the slubbing is passed to the spindles, where it is given its first twist and is then wound on bobbins.

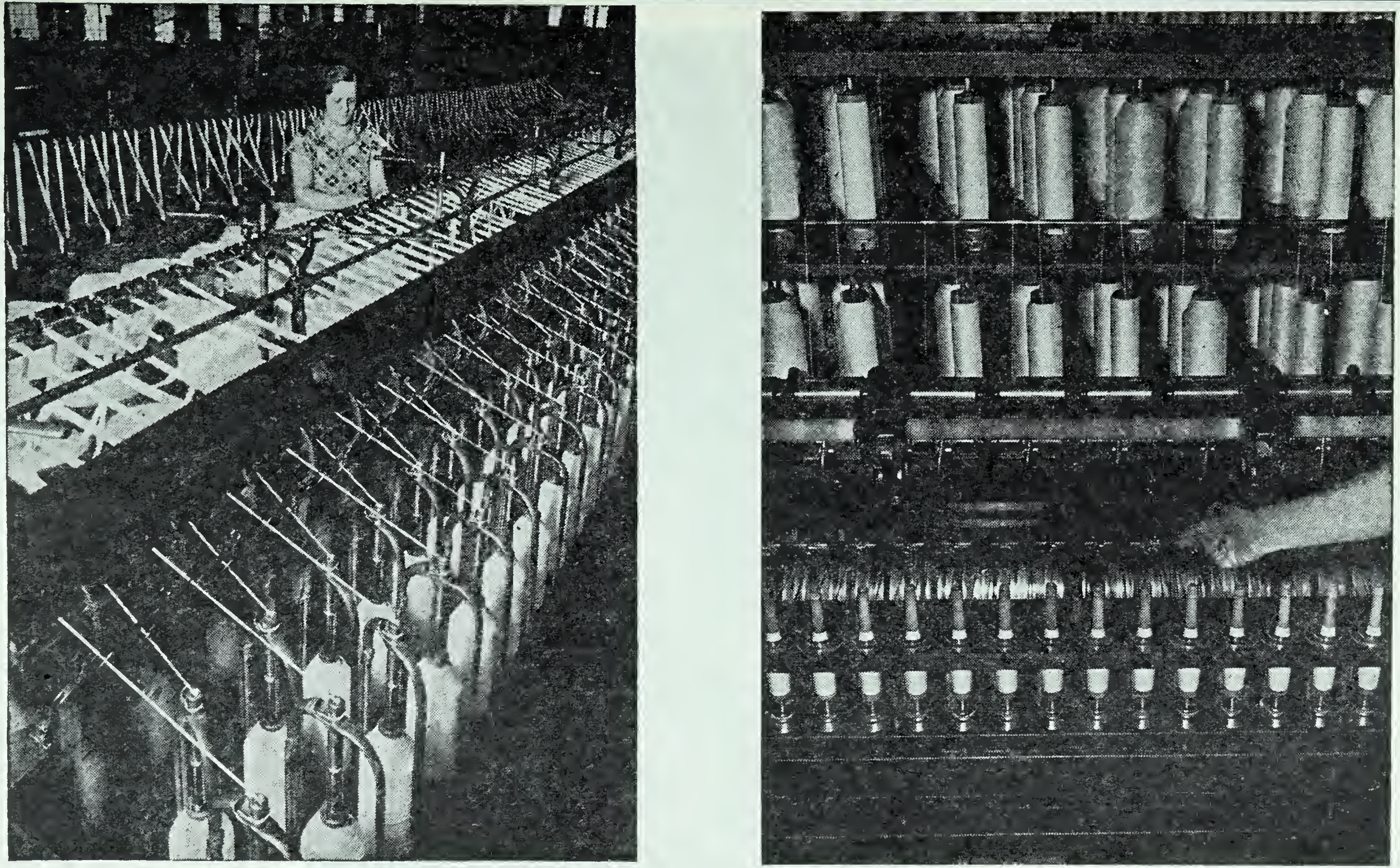


The drawing frame continues the process of drawing out the slivers, reducing them to smaller diameters.

These bobbins are placed on the roving frame, where further drawing out and twisting take place until the cotton stock is about the diameter of a pencil lead.

There are two stages of roving: intermediate and fine. The operations are identical, but each machine yields a finer product than the stock it received.

Roving is the final product of the several drawing-out operations. It is a preparatory stage for the final insertion of twist. To this point, only enough twist has been given the stock to hold the fibers together.

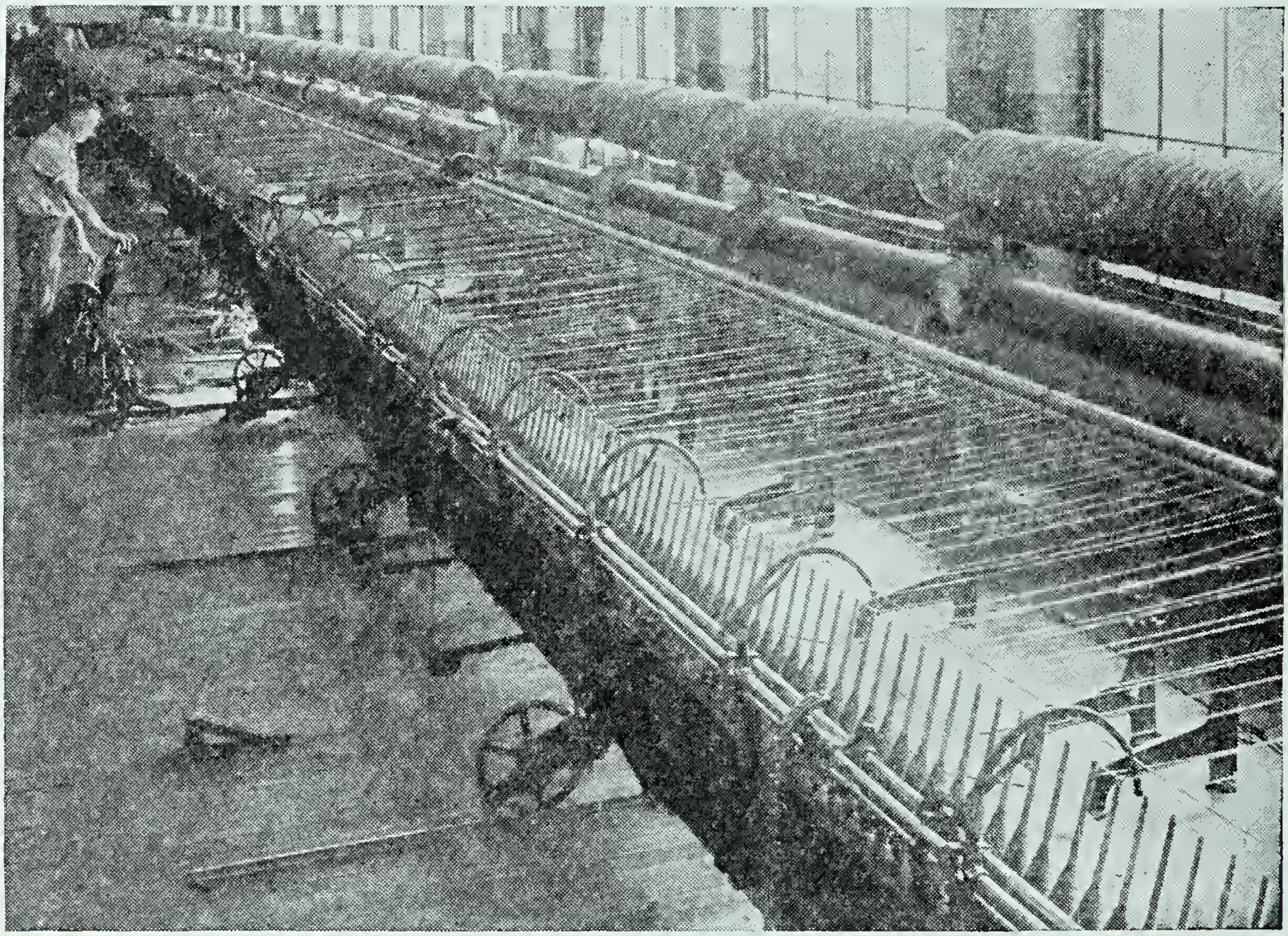


*Left:* In the slubber, further drawing out takes place, and a slight twist is inserted as the thin sliver is wound on bobbins. Three drawing-out processes follow, each resulting in finer sliver with slightly more twist before the sliver is fine enough to be spun. *Right:* In ring spinning, slightly twisted strands on bobbins are passed through a series of rollers to reduce the roving to a desired size.

Roving has no tensile strength; it will break apart easily with any slight pull.

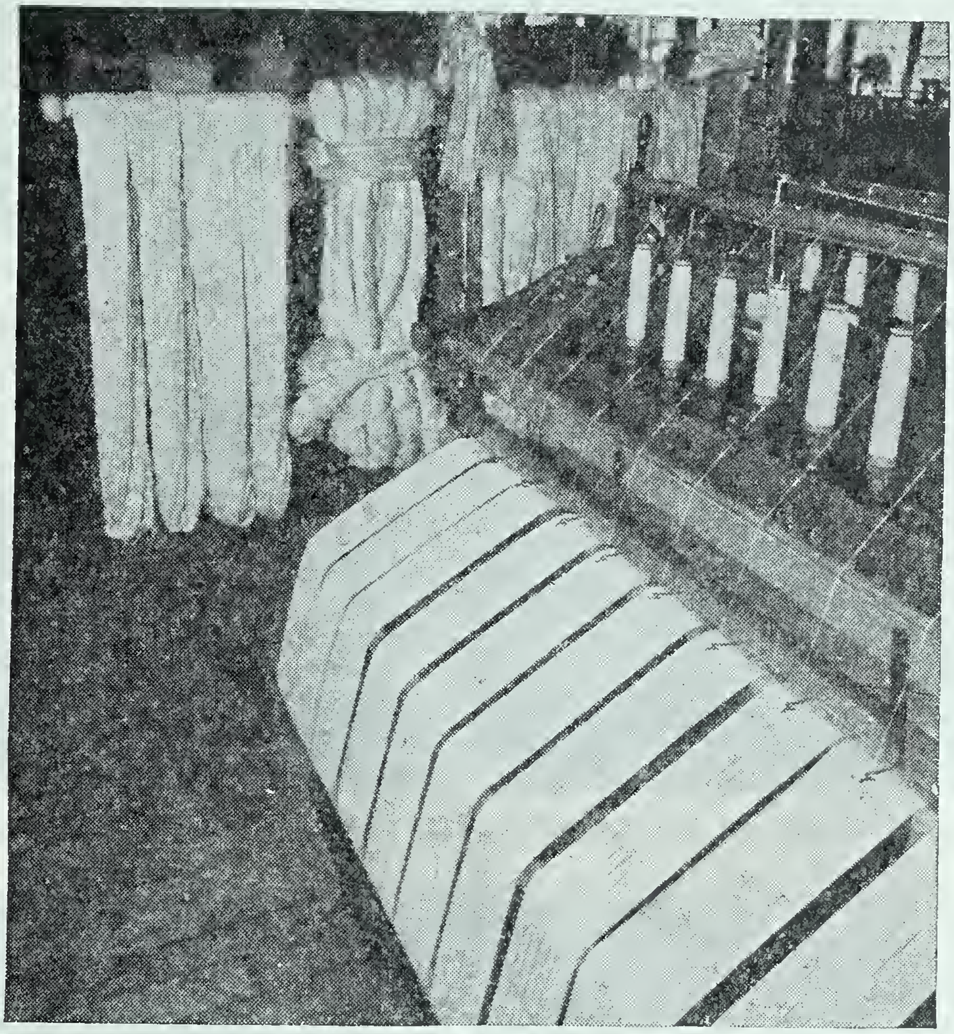
**Spinning.** The roving, on bobbins, is placed in the spinning frame, where it passes through several sets of rollers running at successively higher rates of speed and is finally drawn out to the specified size of yarn desired.

Spinning machines are of two kinds: ring frame and mule frame. The ring frame is a faster process, but produces a relatively coarse yarn. For very fine yarns, the mule frame is required because of its slow, intermittent operation. The ring frame is more suitable for the manufacture of cotton yarns for mass production, because of its hundreds of spindles whirling thousands of revolutions a minute and its constant spinning action, which provides a fast operation.



The mule spinning frame travels forward to draw out the roving, spinning it into yarn of a desired size. As the frame returns to its original position, the yarn is wound on bobbins.

In ring spinning, the roving is passed through an eyelet guide to a small metal loop called a *traveler,* which runs around a metal ring at a very high speed. Inside the ring, a spindle revolves, pulling the traveler after it, and inserts a stipulated number of twists to the finished yarn.

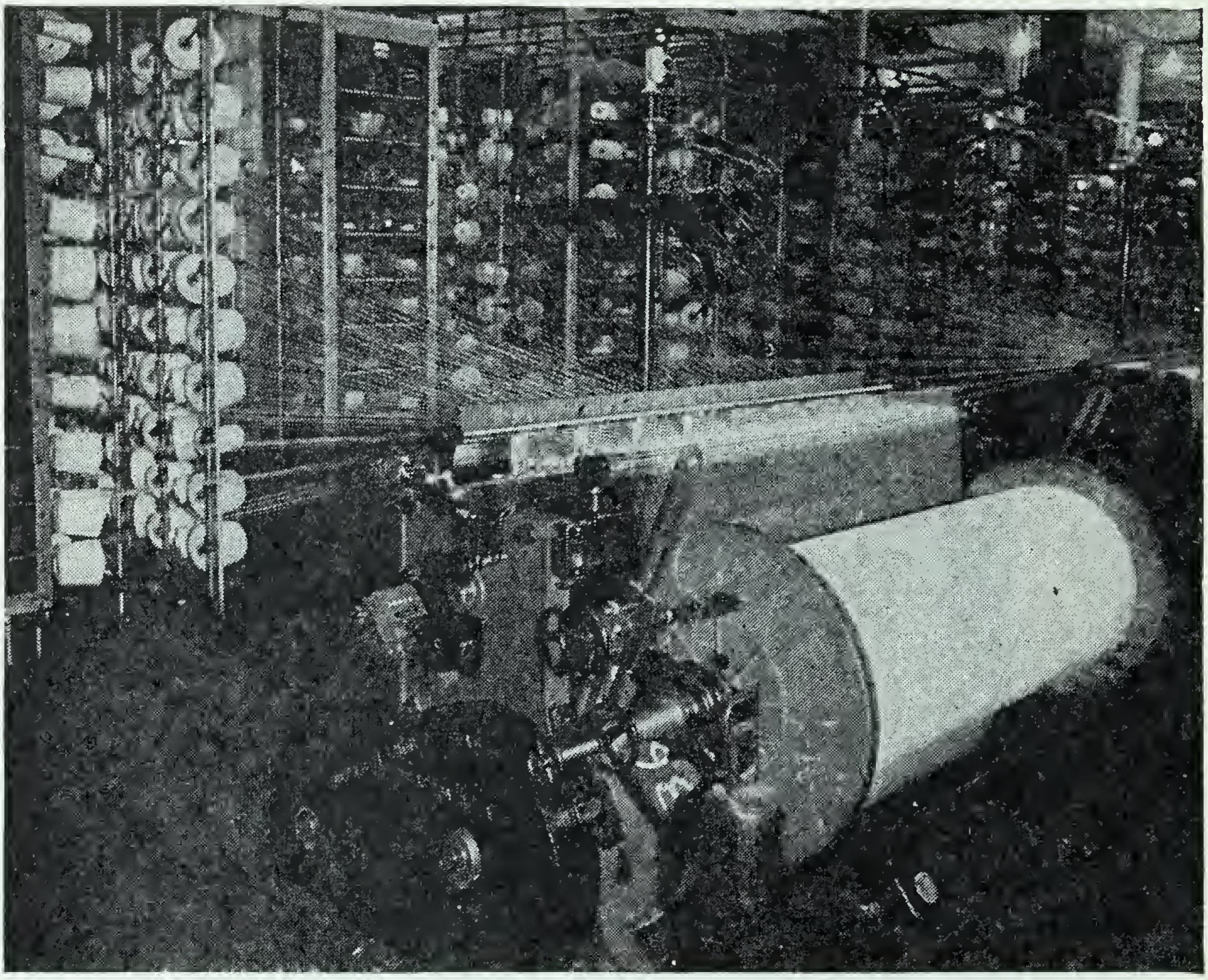


After spinning, yarn is sometimes reeled from bobbins into large skeins ready for bleaching, mercerizing, and dyeing.

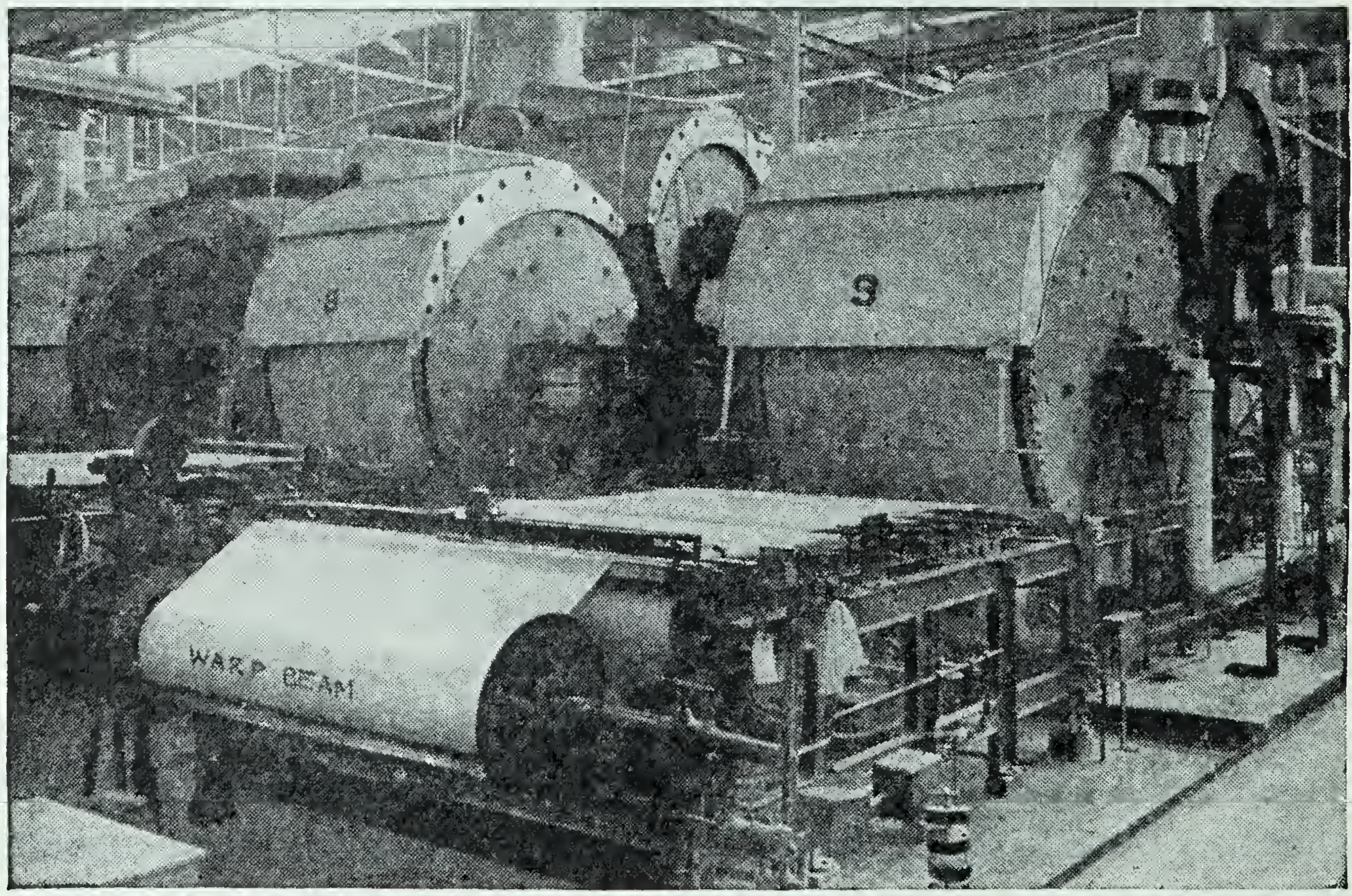
The ring spinning frame completes the manufacture of yarn (1) by drawing out the roving, (2) by inserting twist, and (3) by winding the yarn on bobbins—all in one operation.

**Preparation for Weaving.** In the weaving operation, the lengthwise yarns that form the basic structure of the cloth are called the *warp*. The crosswise yarns are the *filling*, also referred to as the *weft* or the *woof*. The filling yarns undergo little strain in the weaving process. Therefore in preparing them for weaving it is only necessary that they be spun to the desired size and that they be given the amount of twist required for the type of fabric for which they will be used.

Yarns intended for the warp must pass through such operations as



From spools mounted on a creel, separate yarns are wound on a warp beam.



In the slashing machine, the yarns pass from the warp beam into a hot starch bath, which gives them a protective coating for the weaving process.

spooling, warping, and slashing to prepare them to withstand the strain of the weaving process. These operations are not intended to improve the quality of the yarn.

In *spooling,* the yarn is wound on larger spools or cones, which are placed on a rack called a *creel.* From this rack, the yarns are wound on a warp beam, which is similar to a huge spool. An uninterrupted length of hundreds of warp yarns results.

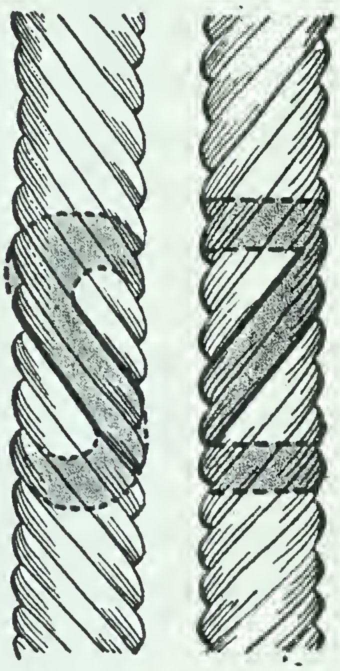
These yarns are unwound to be put through a starch bath called *slashing* or *sizing.* The slasher machine covers every yarn with a starch coating, which serves to prevent chafing or breaking during the weaving process. The yarns are passed over a large copper drum and are heated by steam, to set the sizing. They are then wound on a final warp beam and are ready for the loom.

**Amount of Twist.** The amount of twist to the inch is an important factor in finished consumers' goods. It determines the appearance as well as the durability and serviceability of a fabric. Fine yarns require more twist than coarse yarns. Warp yarns are given more twist than are filling yarns. The amount of twist also depends on the type of fabric for which the yarns will be used. For example:

1. Yarns intended for soft-surfaced fabrics are given only a slack twist. They are called *soft-twisted yarns.*

2. Yarns intended for smooth-surfaced fabrics are given many twists to the inch. Such *hard-twisted yarns* contribute strength, smoothness, elasticity, and some crease resistance to fabrics.

3. Yarns intended for crepe-surfaced fabrics are given a maximum amount of twist. In this case, the direction of twist is also important and contributes crease resistance. Direction of twist may be observed by holding a yarn in a vertical position. If the spirals conform to the direction of the slope of the central part of the letter S, the yarn has an S twist; if they conform to the slope of the letter Z, the yarn has a Z twist.



An S twist and a Z twist are diagramed here.

Permanent crepe effects, such as chiffon, georgette, crepe de chine, canton, flat, and French crepes, are produced by the use of hard-twisted yarns, some of which have left twist, others right twist. These yarns are placed alternately in the warp or in the filling, or in both. When the finished cloth is later washed or dyed, such yarns kink in different directions, producing the crepe surface.

Another satisfactory method of obtaining crepe effects during the construction of the cloth is by the use of slack warp yarns, which may or may not be wound on a separate warp beam. These yarns are held less taut than the other warp yarns and produce a permanent crinkled pattern. Seersucker and matelassé are produced in this way and prove very serviceable.

**Yarn Count.** In the spinning process, there is always a fixed relation between the weight of the original quantity of fiber and the length of the yarn produced from that amount of raw material. This relation indicates the *size of the yarn.* It is determined by the extent of the drawing-out process and is designated by numbers, which are called the *yarn count.*

The standard for the yarn count in cotton is 1 pound of fiber drawn out to make 840 yards of yarn; the resultant size or thickness is known as count No. 1. If the yarn is drawn out further, so that 1 pound makes twice 840 yards, it is identified as No. 2. It may be seen that a No. 2 yarn will, naturally, be finer than a No. 1. No. 10 denotes a still finer yarn, as it indicates that 1 pound of cotton is drawn out to ten times 840 yards. The higher the number of the yarn count, the finer the yarn in size.

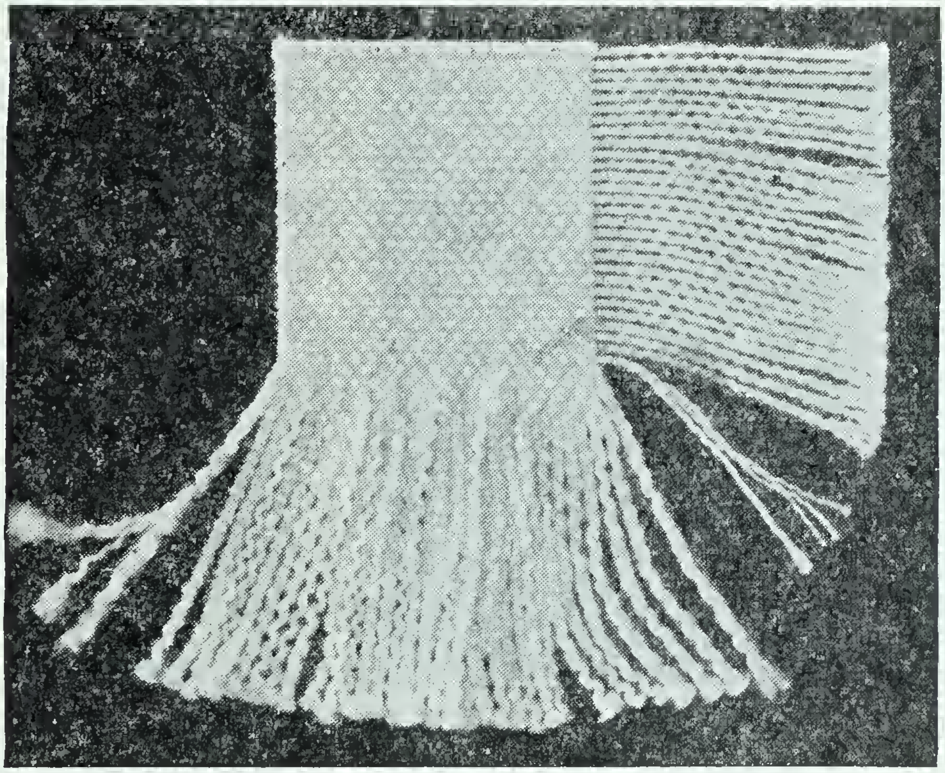
Yarn counts up to 20 are called coarse yarns; 20 to 60 are medium yarns; above 60 are fine yarns. Up to 20, the count rises by single numbers. Only even numbers are used between 20 and 60. Above 60, the count rises by intervals of 5 until 100, after which an interval of 10 is used.

The size of mercerized cotton sewing thread used for general purposes is No. 50 or No. 60. The finest yarn ever made in the United States was No. 160, the product of 1 pound of cotton drawn out to a strand 134,000 yards long (over 76 miles). The very finest cotton yarns spun in England have been as high as No. 400; but extremely fine yarns are difficult and costly to manufacture because of the greater care required in spinning and the greater amount of twist to the inch.

The size of yarn to be used in a certain fabric is determined by the purpose of the fabric. Yarns of varying sizes may be used in order to obtain the nubbed or novelty effects and rough textures characterized by ratiné, bouclé, or éponge.

**Ply Yarns.** When two or more strands or yarns are twisted together, they are designated as *ply yarns.* They are termed two-ply, three-ply, and so on, according to the number used in their construction.

A single yarn may be of relatively good quality; but where durability is all important, ply yarns are preferable, assuming that the yarns have the same length of staple. Good-quality broadcloth for men's shirtings, for example, is made with ply yarns.

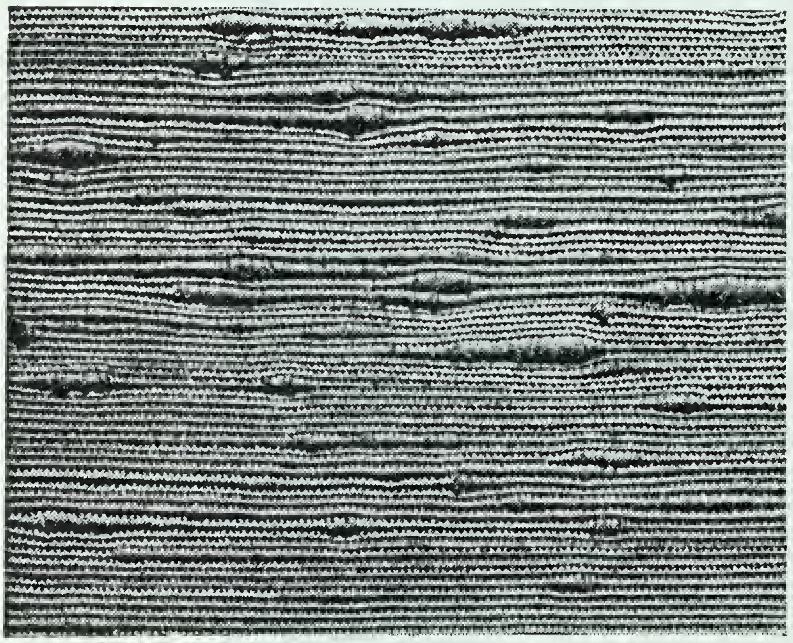


This sample of duck fabric shows how the use of ply yarns produces compactly woven cloth of great strength.

Yarn construction and yarn count are expressed in the following manner. The term 1/30s denotes the use of a single yarn having a yarn count of 30. In the same way, 3/30s denotes the use of a three-ply yarn; that is, three strands twisted together, each having a separate yarn count of 30. A three-ply yarn, indicated by 3/30s, would be equivalent to a single yarn having a yarn count of 10. In the same way, 2/10s (containing two single strands of 10s) is equivalent in size to 1/5s.

When the number of yards in a pound of cotton is to be calculated for any given size of yarn, the yarn count is multiplied by 840 yards. For example, if the required size of a yarn is 2/10s, the fraction should be reduced to 1/5s; then the 5 is multiplied by 840; the result is 4,200 yards.

**Doubled Yarns.** Another type of yarn construction is the doubled yarn. This consists of two or more single strands treated as one in the weaving process; but the strands are not twisted together. The doubled yarn must not be confused with ply yarns, which are stronger because they are twisted. Doubled yarns are used for ornamental effect; they do, of course, contribute a certain amount of additional strength. Because doubled yarns have little twist, they produce luster and softness.



The soft untwisted parts of slub yarns, which are the result of an incomplete spinning process, produce interesting irregularities in finished cloth.

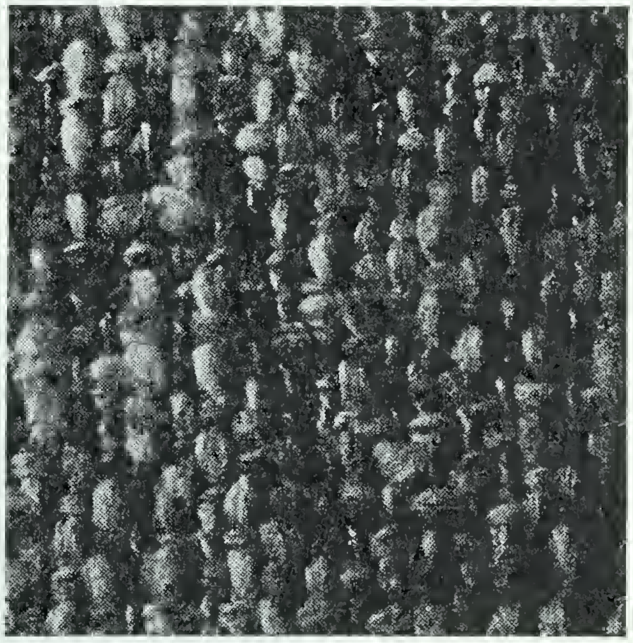
**Slub Yarns.** The consumer's desire for ornamental effects has popularized the production of yarns that are given only a small amount of drawing out. Such yarns, which are called *slub yarns,* have soft untwisted areas at frequent intervals throughout their length. They are coarse, with slight twist, having varying diameters that show irregularities typical of an incomplete spinning operation.

If simulation of linen is desired, the use of slub yarns is easily understood. Where durability is a main consideration, however, their practicability is justly questioned, because a heavy yarn protruding above the level of surrounding yarns on the surface of a cloth is subjected to friction, and the fabric soon shows signs of wear after continued use.

In the past, slub yarns were generally used in fabrics that possessed an especially compact construction and consequently were characterized by marked durability. Today, slub yarns do not always imply compact construction in the fabric of which they are a part. They do furnish ornamental effects, and are frequently used for that purpose in cotton broadcloths and tweeds.

**Complex Yarns.** The spinning process can produce decorative effects also by varying the amount of twist or by twisting together yarns of different diameters. Bouclé and ratiné fabrics are the most common examples of complex yarns. They are made by twisting together two or more yarns under different spinning tensions, thus producing irregularities at intervals along the surface of the yarn.

Other novelty effects can be obtained by using one yarn as a core or base and winding a second yarn around this core. When the inner yarn is of an inferior grade, the product may be regarded as an adulteration, although the core gives strength with lessened cost. A safe rule for the consumer is to remember that longer service may be expected from fabrics made from evenly spun yarns rather than from novelty yarns of complex character.



Novelty yarns produce the attractive nubby effects seen in tweeds.

**Cloth Count.** The durability of a fabric depends on: (1) the kind and quality of the fiber, (2) the tensile strength of the yarn, (3) the amount of twist in the yarn, (4) the use of ply yarns as compared with singles, and (5) compactness of construction.

Compactness is one of the most significant factors when considering the durability of a fabric. It is determined by the closeness of the yarns after the cloth is woven. A closely woven fabric has a larger quantity of yarns than a loosely woven one, and is therefore more serviceable. A garment made from such a fabric shrinks less in washing, slips less at the seams, and is more apt to keep its shape.

A fabric of compact construction has a high cloth count. *Cloth count,* also known as *thread count,* is determined by counting the number of warp yarns and filling yarns in 1 square inch. These yarns are commonly referred to as *ends* and *picks,* terms that are synonymous with *warp* and *filling,* respectively.

To ascertain the cloth count, it is necessary to have a pick glass, sometimes called a thread counter, which is a magnifying glass mounted on a small stand with a square opening in its base. Through this opening, warp and filling yarns are magnified and counted. If the square opening is a ¼-inch size, the number of yarns counted in the quarter inch, when multiplied by 4, gives the number of yarns in 1 inch of the fabric. Some pick glasses have a ½-inch square opening; others have a full square inch. The largest size is preferable as the possibility of error in computation is minimized.

Determining cloth count.

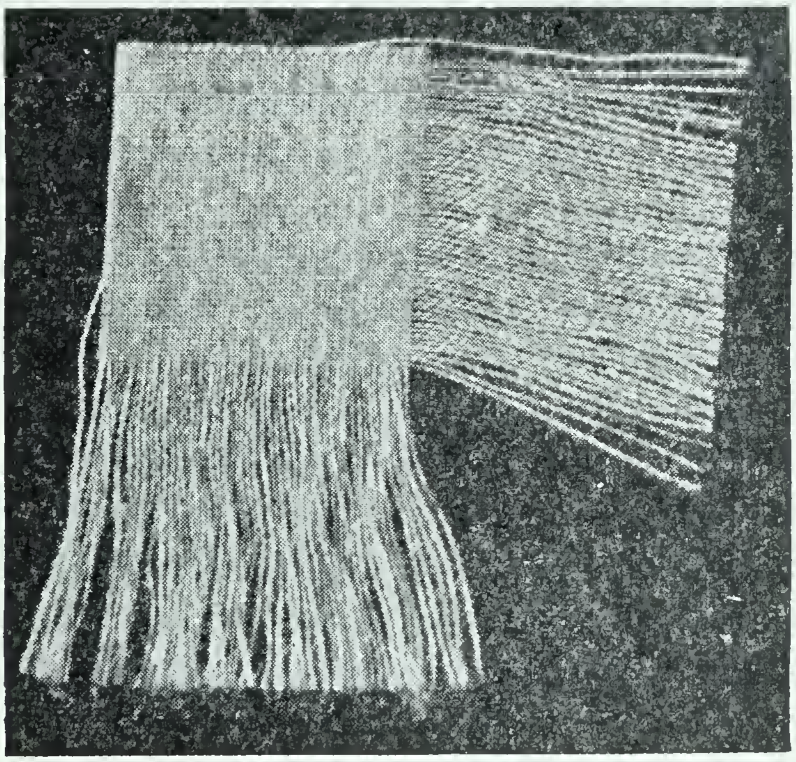
Cloth count should not be confused with yarn count. Yarn count measures the degree of fineness in yarns; cloth count measures the number of warp and filling yarns in a square inch of fabric. While these counts are separate devices of measurement, there is a direct relationship between them. If coarse sheeting with a low cloth count is to be constructed, for example, thick or coarse yarns will be used. These give the fabric greater resistance to hard wear.

*Typical Cloth Counts.* Cloth counts range from as low as 20 threads to the inch, used in tobacco cloth, to as high as 350 threads to the inch, found in typewriter-ribbon fabrics.

An example of cloth count used as a standard may be illustrated by the Government specifications for cotton sheets (see chart in Chapter VIII), which stipulate a minimum cloth count of 74 × 66, or a total cloth count of 140 threads to the square inch. This specification means that each sheet must have 74 warp yarns and 66 filling yarns to the square inch. The first number indicates the warp; the second is the filling.

With some finished goods, such as sheeting, cloth count is sometimes given as a single number, which is the addition of warp and filling. Thus a 74 × 66 is described as a 140.

*Balanced Construction.* A fabric is said to be well balanced if the number of warp yarns and filling yarns are almost equal. For example, a piece of muslin with a cloth count of 64 × 60 is considered well balanced. A piece of gauze with a cloth count of 28 × 24 is also well balanced.



Perfectly balanced cloth construction is shown in this sample of sheeting; the number of warp and filling yarns is the same.

In contrast, a broadcloth with a count of 100 × 60 has poor balance. Although good balance of warp and filling produces a fabric with good wearing qualities, a balanced construction is not always obtainable with certain staple fabrics. Broadcloth shirting, for example, uses twice as many warp yarns as filling yarns. Therefore the nature of its construction makes it impossible for it to be well balanced according to cloth count; yet it is a durable fabric if its cloth count is high.

Sometimes a fabric may have good balance in its cloth count, but it may be altogether unsatisfactory because of weakness in either warp or filling yarns. Therefore, the factor of tensile strength of both sets of yarns must always be taken into consideration when a fabric is being judged. Both yarn count and cloth count determine the suitability and value of finished goods. A safe rule for the consumer to remember is that high-count cloth even with poor balance will give better wear than low-count cloth with good balance.

*Test yourself on this chapter by answering these questions:*

1. How are fibers made into yarns?
2. Describe the carding process and what it does to the cotton fibers.
3. Explain why a fabric woven from slub yarns may not wear well.
4. Why would it be difficult to make cloth directly from a roving?
5. What is meant by yarn count? Why is it important?
6. Why is cloth count especially important?
7. In what way do differences in the raw material affect the formation of yarn?
8. Compare the carding and the combing processes.
9. Explain the processes involved in the manufacture of yarn. Use a rough diagram to illustrate your explanation.
10. What are the qualities that determine the value of the yarn?
11. Explain the meaning of 1/60s, 4/20s, 3/30s.
12. Explain the difference between ply yarns and doubled yarns.
13. How is variation in yarns obtained in the spinning process?
14. How does twist in a yarn affect the finished fabric?
15. For what kind of fabrics are yarns given a very slack twist in spinning?

## Suggested Readings

Dooley, W. H., *Textiles,* Chapter 8.
Dyer, E., *Textile Fabrics,* Chapter 4.
Hess, K. P., *Textile Fibers and Their Use,* Chapter 2, Section 1.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 2.
Nystrom, P. H., *Textiles,* Chapter 3.
Small, C. P., *How to Know Textiles,* Chapter 6.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 2.

## CHAPTER IV

# YARN TO CLOTH: WEAVING

The second stage of development of fiber into fabric is the weaving process. Although there are other methods of cloth construction, that of weaving, or interlacing, yarns has foremost place.

It is believed that the interlacing or weaving process became known to primitive man before spinning. At first, materials available for weaving were used in their natural state, just as they grew. As time passed, spinning slowly developed because man discovered that the raw materials could be changed somewhat and improved before they were woven.

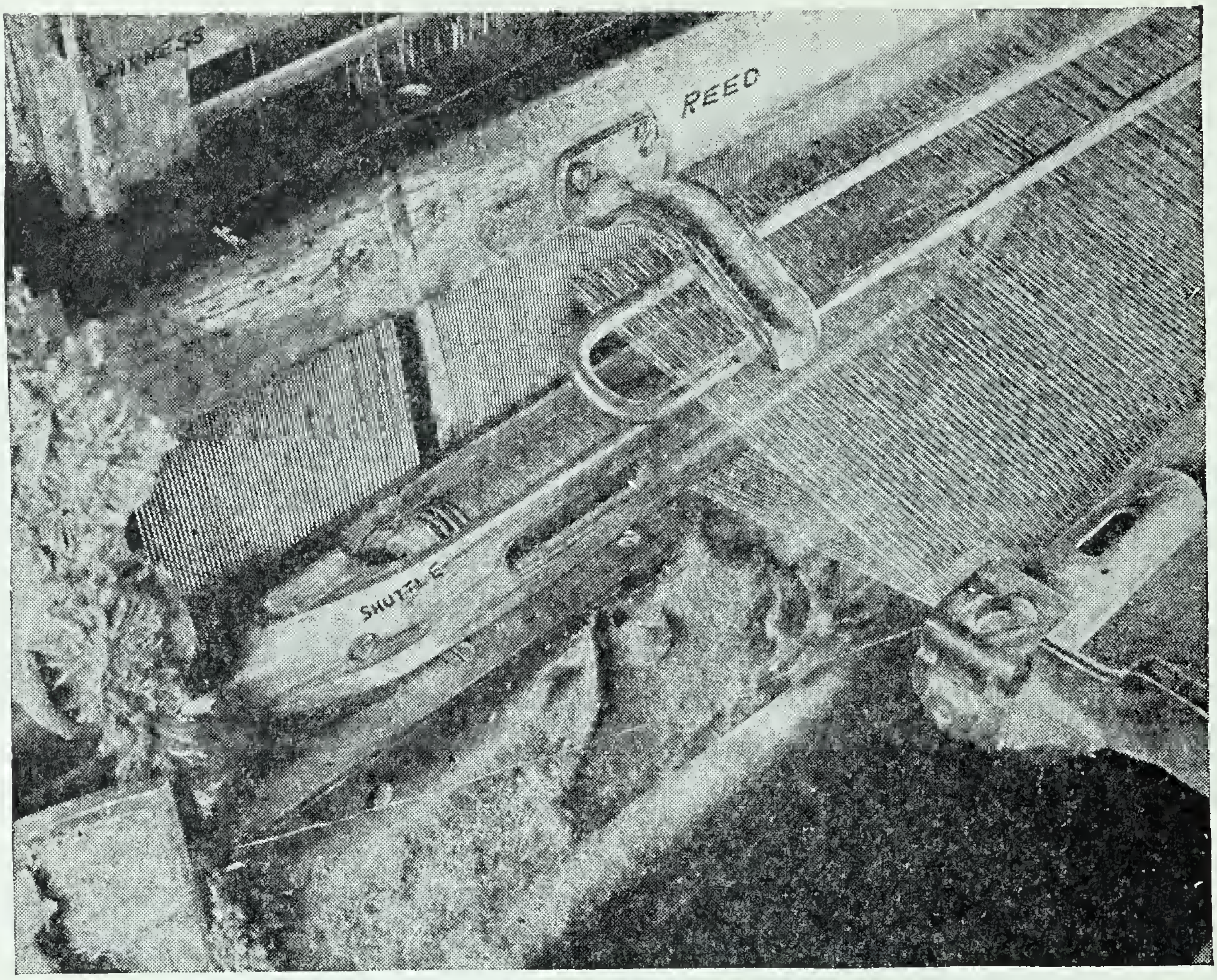
It is not known how knowledge of interlacing was first acquired, but presumably primitive man discovered that he could make protective clothing for himself and thatchlike huts and fences by observing the interlaced grasses and twigs in the nests of birds; or he may have seen rushes naturally interlacing as they grew.

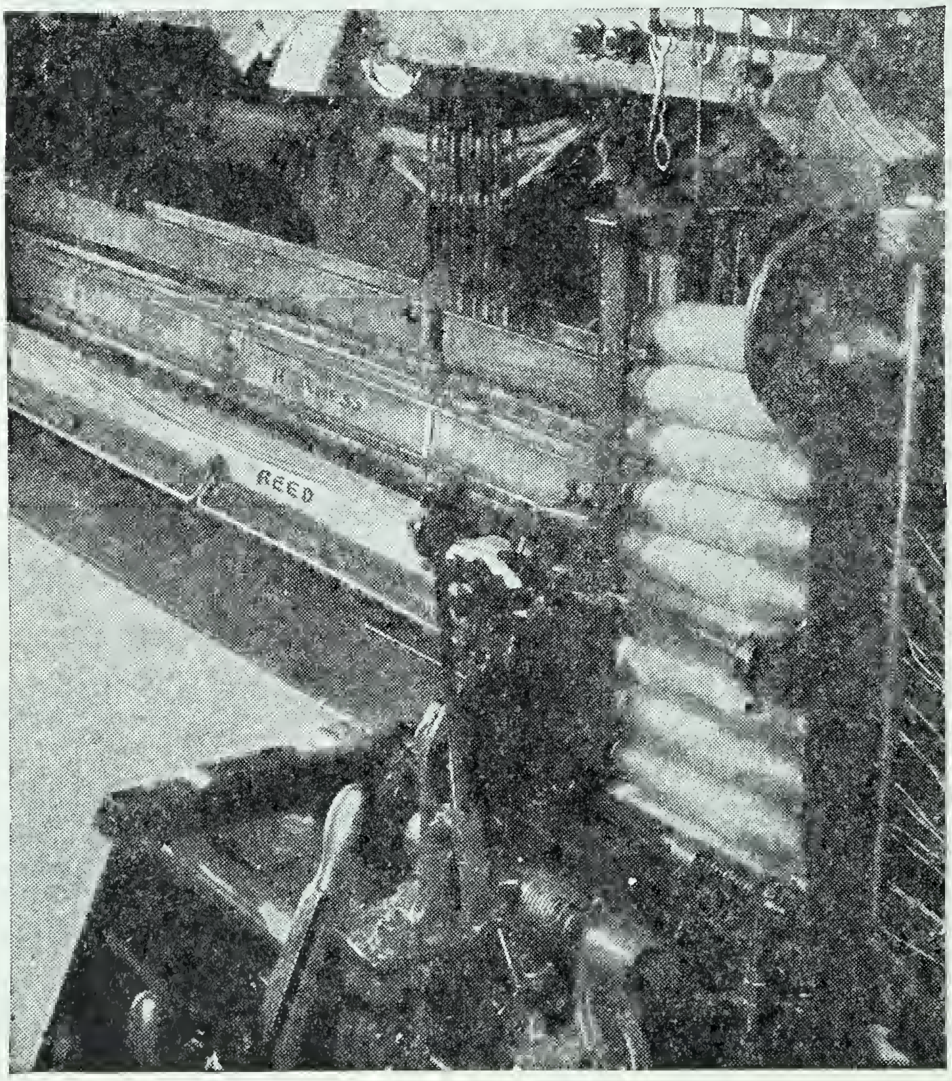
In the course of time, rude looms were made, which were crudely simple and hand operated. Yet the modern power loom used in the textile industry today contains essentially the same parts and performs the same operations as the simplest hand-operated loom.

**Essential Weaving Operations.** On the modern loom, the warp yarns are wound on a cylinder called the *warp beam,* which is at the back of the loom. The warp extends to another cylinder called the *cloth beam* at the front of the loom. The cloth is rolled on the cloth beam as it is constructed. Supported on the loom frame between these two cylinders, the warp yarns are ready to be interlaced by the filling yarns, which thus produce the woven fabric.

In any type of weaving, four operations are fundamental. They are performed in sequence, and are constantly repeated. If these operations are carefully noted, the more varied and advanced constructions of cloth will be readily understood.

The essential parts of the loom are: warp beam, cloth beam, har-





*Above:* This loom in operation shows how the harness and heddles (in the upper left) are lifting and lowering units of warp yarns to form the shed through which the shuttle is passing. The reed automatically moves forward to batten each newly woven yarn.

*Left:* This view of another loom clearly shows a filling yarn after the shuttle has interwoven it with the warp and just before the reed has battened it against the constructed cloth. Replacement bobbins are shown at the right.

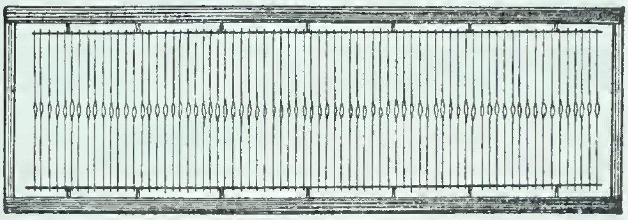
ness or heddle frame, shuttle, and reed. These parts are used to perform the following operations:

1. Shedding—*raising* warp yarns by means of the *harness* or *heddle frame.*
2. Picking—*inserting* filling yarns by means of the *shuttle.*
3. Battening—*pushing* filling yarns firmly in place by means of the *reed.*
4. Taking up and letting off—*winding* the finished cloth on the *cloth beam,* and at the same time *releasing* more of the warp from the *warp beam.*

*Shedding.* On the primitive loom, in order to insert the filling yarns into the warp, the weaver had to raise each alternate warp yarn with his finger or by means of a stick. Weaving was therefore a very slow process. The raising of the warp yarns formed an opening, or shed, through which the filling yarn was inserted. This first weaving operation therefore became known as *shedding.*

The bobbin of filling yarn lies inside the shuttle, and the yarn is pulled through a small opening in the side as the shuttle moves swiftly across the loom.

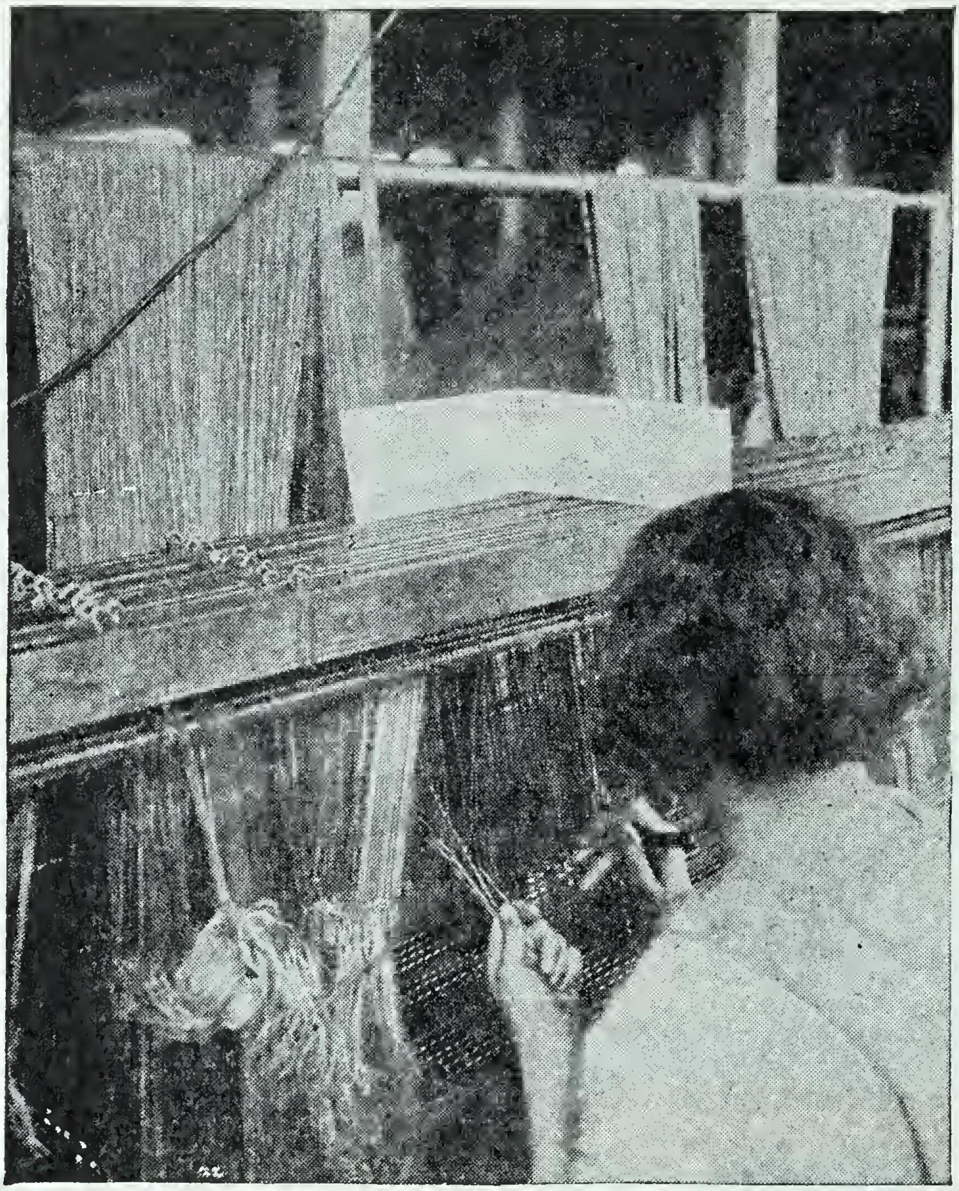
On the modern loom, simple and intricate shedding operations are performed automatically by the heddle frame. This is a rectangular frame to which a series of wires, called heddles, are attached. As the warp yarns come from the warp beam, they must pass through openings in the heddles. Each opening may be compared to the eye of a needle. The operation of drawing each warp yarn through its appropriate heddle is known as *drawing in.*



This drawing shows how a harness frame holds several heddles in one unit. Warp yarns pass through the eyes of the heddles (shown in center), and are raised or lowered as one unit in the weaving operation.

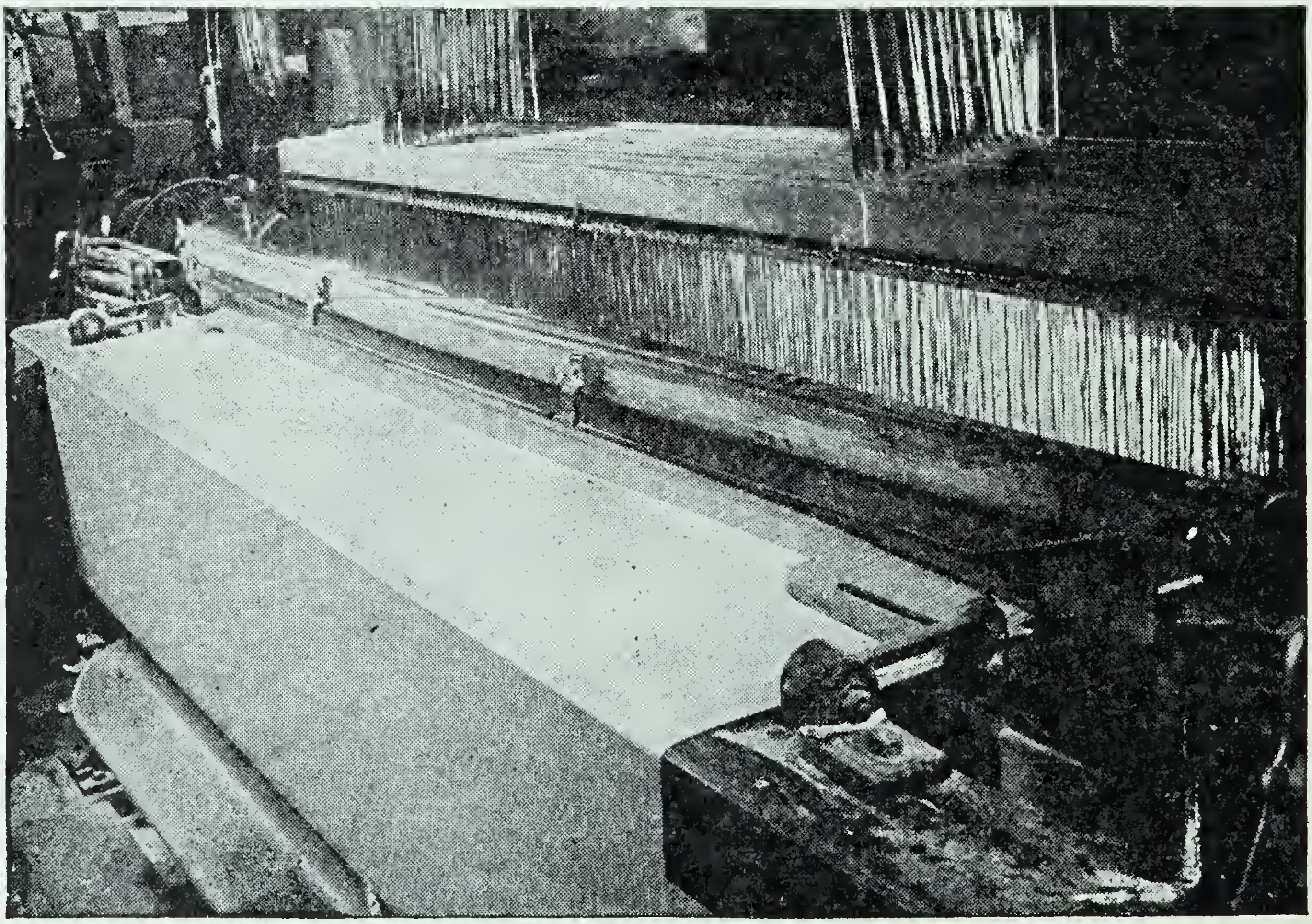
In the simplest weave construction, the heddle frame raises or lowers certain groups of alternate warp yarns so that the filling yarns alternate in passing under one group of warp yarns and over another.

The heddle frame is better known as the harness, and that term



*Left:* In the drawing-in process, each warp yarn must be drawn through its assigned heddle. This is determined by the construction design on the white card, which can be seen in this picture on the top of the machine. The warp units are then drawn through the reed.

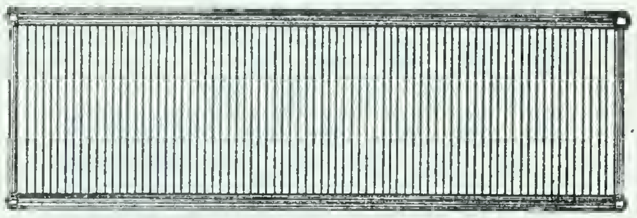
*Below:* The more intricate the design of the cloth to be woven, the more harnesses must be placed on the loom. Here are shown the many harnesses (at the back of the loom) that move up and down according to the design followed during the drawing-in process.



is used hereafter because it will be necessary to refer to the number of harnesses used for the different types of weaves.

*Picking.* As the harnesses raise the heddles, which raise the warp yarns, the filling yarn is inserted through the shed by a small carrier device called a shuttle. The shuttle contains a bobbin of filling yarn, which emerges through a hole in the side as the shuttle moves across the loom. One passage of the shuttle from one side of the loom to the other is known as a *pick*.

*Battening.* All warp yarns pass through the heddle eyelets and through openings in another frame that resembles a comb and is called a *reed*. With each picking operation, the reed pushes automatically, or battens, each filling yarn against the portion of the cloth that has already been formed. This third essential weaving operation is therefore called *battening*. It gives the cloth a firm compact construction.



The reed resembles a large comb. The warp yarns are evenly separated and held parallel as they pass between the teeth.

*Taking Up and Letting Off.* With each shedding, picking, and battening operation, the newly constructed cloth must be wound on the cloth beam. This process is known as *taking up*. At the same time, the warp yarns must be released from the warp beam; this is referred to as *letting off*. The cloth beam can be seen in the lower left on the opposite page.

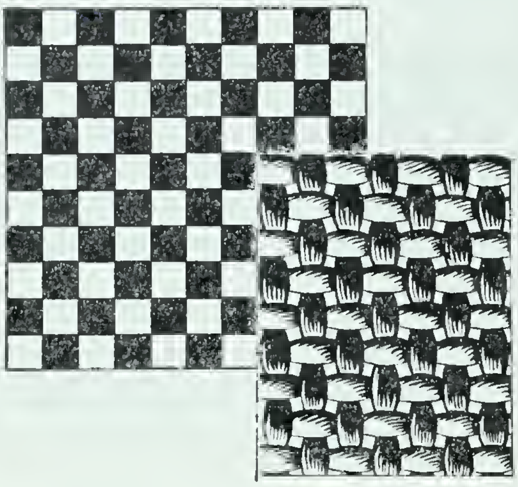
**Classification of Weaves.** The manner in which groups of warp yarns are raised by the harnesses to permit the insertion of the filling yarn determines the pattern of the weave, and in large measure the kind of cloth produced. Weave patterns can create varying degrees of durability in fabrics, adding to their usefulness and also to their appearance.

In a simple weave construction, consisting of under one warp and over the next, two harnesses are needed: one to lift the odd-numbered warp yarns, and a second to lift the even-numbered warp yarns. For advanced weaves, more than two harnesses are required, and as many as forty may be necessary for the figured weaves.

The three basic weaves in common use for the majority of fabrics are plain, twill, and satin, with respective variations. Important constructions are also obtained from the following weaves: pile, double-cloth, gauze, swivel, lappet, dobby, and Jacquard.

**Construction of Cloth Designs.** In the textile industry, a pattern of the weave to be used in the construction of a fabric is designed on cross-sectioned paper. A draft of the design of the weave is indispensable when setting up a loom for a particular weave or color effect as it indicates the particular harness and heddle through which each warp yarn is to be drawn.

The student may obtain a working knowledge of weaves by reproducing such designs on graph paper and then carrying out the actual weaving operations on a miniature loom made of stiff cardboard or a cigar box.



The construction design for the plain weave resembles the familiar checkerboard. The way in which filling yarns pass under and over alternate warp yarns is shown at the right. When cloth is closely constructed in the plain weave, there is no distinct pattern.

**Plain Weave.** The plain weave is sometimes referred to as the tabby, homespun, or taffeta weave. It is the simplest type of construction, and is consequently inexpensive to produce. On the loom, the plain weave requires only two harnesses.

Each filling yarn goes under and over the warp yarns across the width of the cloth; on its return, the yarn alternates the pattern of interlacing. If the yarns are close together, the plain weave has a high cloth count, and the fabric is therefore firm and will wear well.

As the manufacture of the plain weave is relatively inexpensive, it is used extensively for cotton fabrics and for fabrics that are to be decorated with printed designs, because the surface that it produces is especially receptive to a direct print.

The appearance of the plain weave may be varied by differences in the closeness of the weave, by different thicknesses of yarn, or by the use of contrasting colors in the warp and filling. The last method gives the effect of a design. In addition, two variations of the plain weave afford simple decorative effects; namely, the basket weave and the ribbed, or corded, weave.

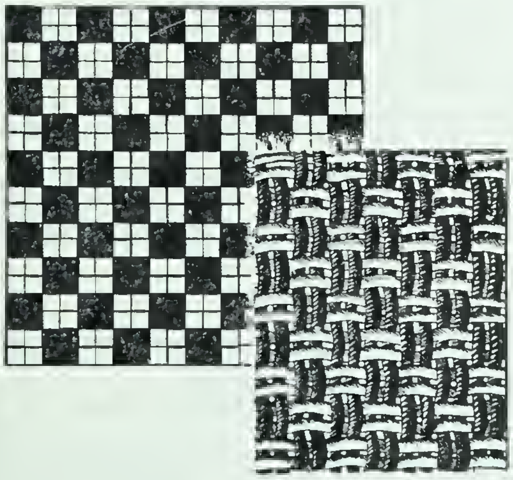
*Fabrics in Plain Weave.* In cotton: batiste, broadcloth, bunting, calico, cambric, challis, chambray, cheesecloth, chintz, crash, crepe, crinoline, cretonne, duck or canvas, flannelette, gingham, Indian head, lawn, longcloth, muslin, madras, nainsook, oilcloth, organdy, osnaburg, outing flannel, percale, percaline, ratiné, seersucker, scrim, sheeting, tarlatan, voile.

In linen: airplane cloth, art linen, cambric, crash, dress linen, handkerchief linen, sheeting, theatrical gauze.

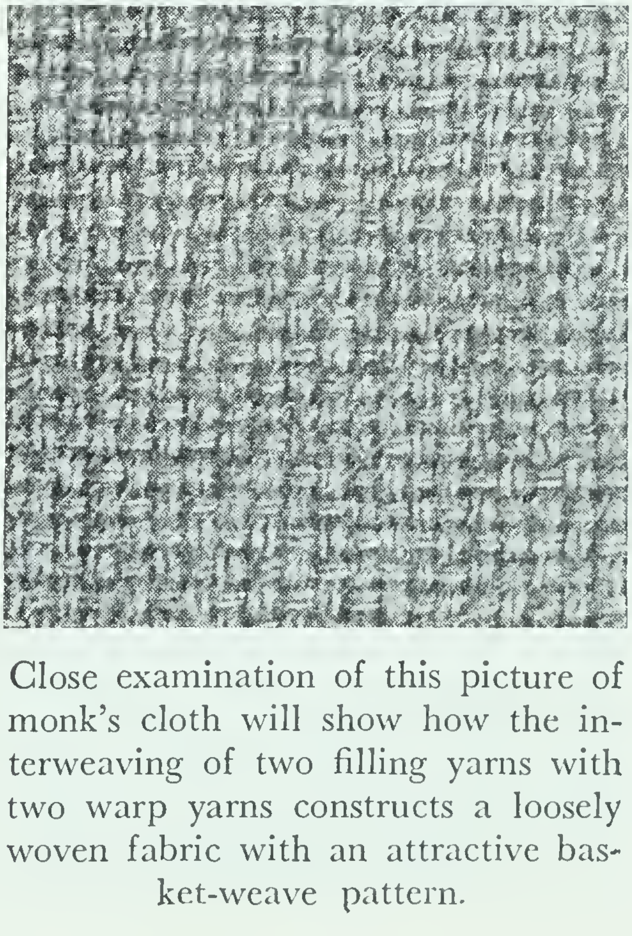
In wool: albatross, blanket cloth, challis, flannel, homespun, nun's veiling, tweed.

In silk or rayon: canton crepe, chiffon, China silk, flat crepe, georgette, habutai, mousseline de soie, radium, shirting silks, taffeta, voile, crepe de chine.

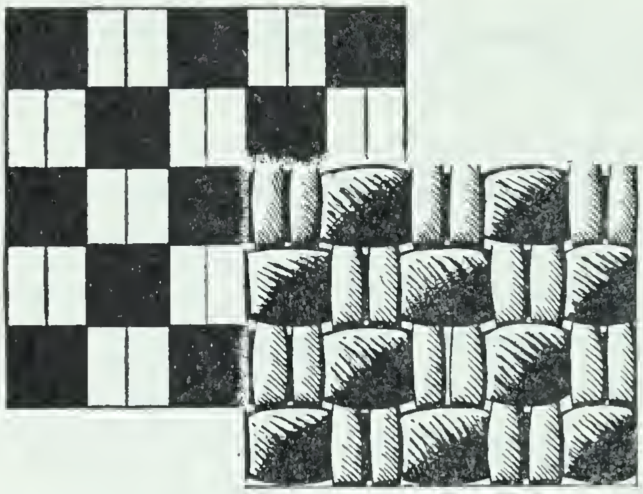
*Basket Weave.* The variation of the plain weave known as the basket weave uses doubled yarns to produce the design that resembles the familiar pattern of a basket. Two or more filling yarns with little or no twist are interlaced with a corresponding number of warp yarns. They are woven in a pattern of 2 × 2, 3 × 3, or 4 × 4, instead of 1 × 1, which is the pattern of the plain weave.



The basket weave is a variation of the plain weave. Two (instead of one) filling yarns pass under and over two (instead of one) warp yarns. This weaving method results in a simple, attractive pattern, so named because baskets have long been woven in this manner.



Close examination of this picture of monk's cloth will show how the interweaving of two filling yarns with two warp yarns constructs a loosely woven fabric with an attractive basket-weave pattern.



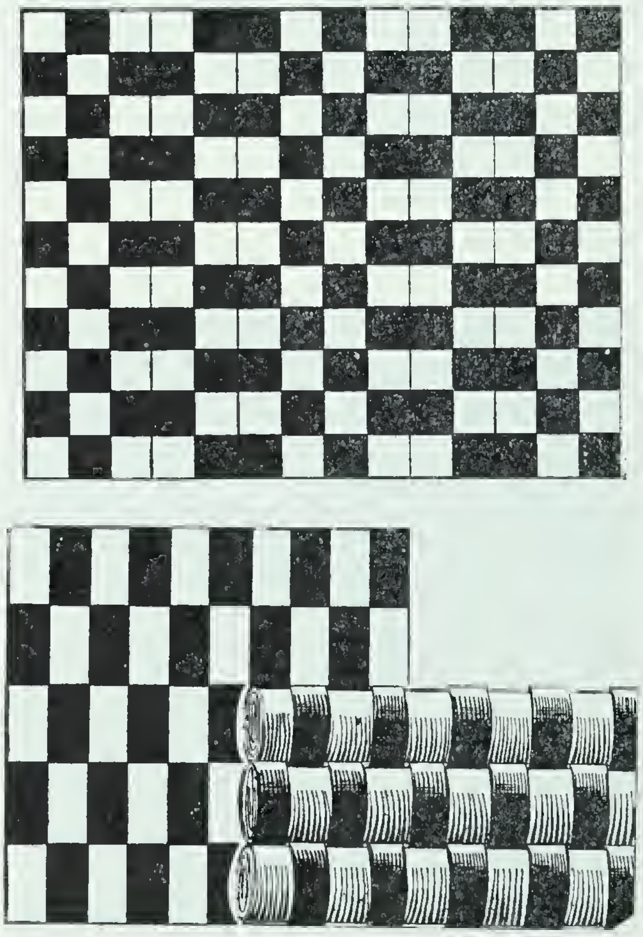
The design for oxford cloth shows how a large filling yarn having no twist is woven under and over two single, twisted warp yarns.

The basket weave produces an attractive loosely woven fabric that stretches easily and hangs well. It is therefore suitable for drapery and covering fabrics, such as monk's cloth. Due to the characteristic looseness of construction and the low tensile strength of yarns that have little or no twist, this weave is not considered desirable for clothing purposes where the factor of durability is a primary consideration.

*Oxford Cloth.* The weave used in the popular oxford shirting varies slightly from the regular basket weave in that it has a 2 × 1 construction; but the size of the single yarn—a coarser yarn used as the filling—is approximately equivalent in size to the two separate warp yarns. As the coarser yarn has no twist, the fabric is of soft texture and has a degree of luster.

*Fabrics in Basket Weave.* In cotton: monk's cloth, hardanger cloth, oxford shirting or suiting, panama cloth.

In wool, silk, or rayon: shepherd's check or plaid.

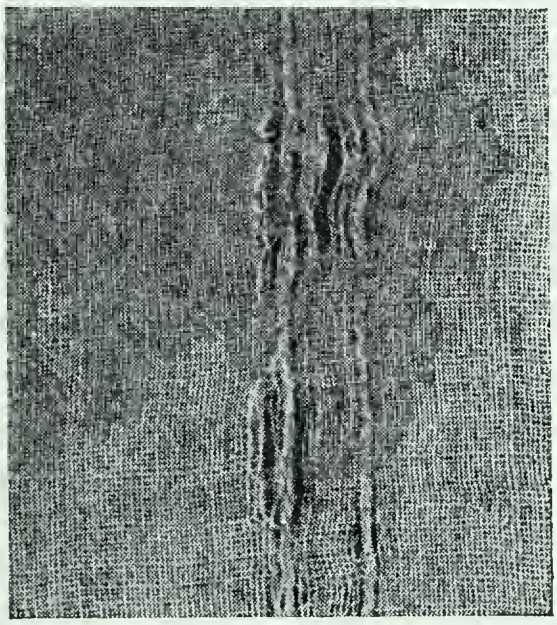


The upper drawing shows a ribbed or corded effect running in the direction of the warp. The lower shows the ribbed effect running in the direction of the filling.

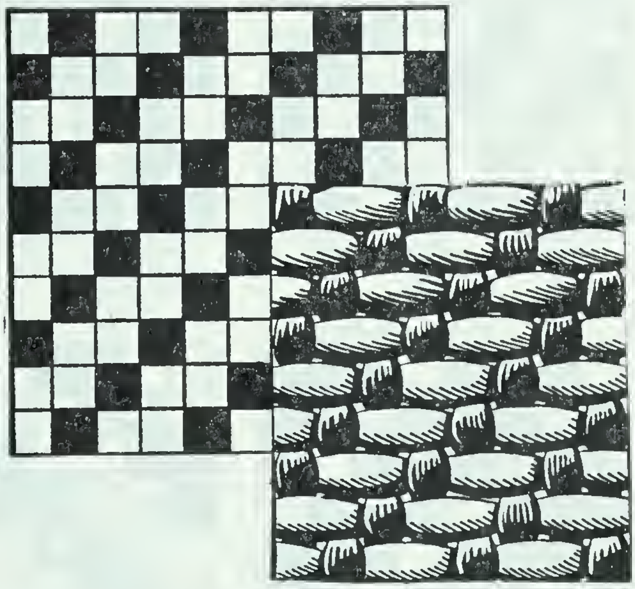
*Ribbed Effects.* Ribbed, or corded, effects are further variations of the plain weave. The rib may be produced in the warp or in the filling by alternating fine yarns with coarse yarns, or single yarns with doubled yarns.

Ribbed effects are popular; but the consumer should remember that sometimes inferior yarns are used in their manufacture, especially when the yarns that make the rib are hidden in the thickness of the cloth. As these yarns do not show on either side of the fabric, sometimes extremely short-staple yarns or yarns with insufficient twist are used.

A ribbed fabric will not be durable if the ribs are too pronounced, because the coarse yarns that produce the rib tend to pull away from adjacent fine yarns. Also, in ribbed effects, an entire yarn is exposed to friction, thus lessening the durability of the fabric.



When too coarse a yarn is combined with fine yarns for a ribbed effect, the fine yarns adjacent to the rib soon break when subjected to strain or to heavy wear.

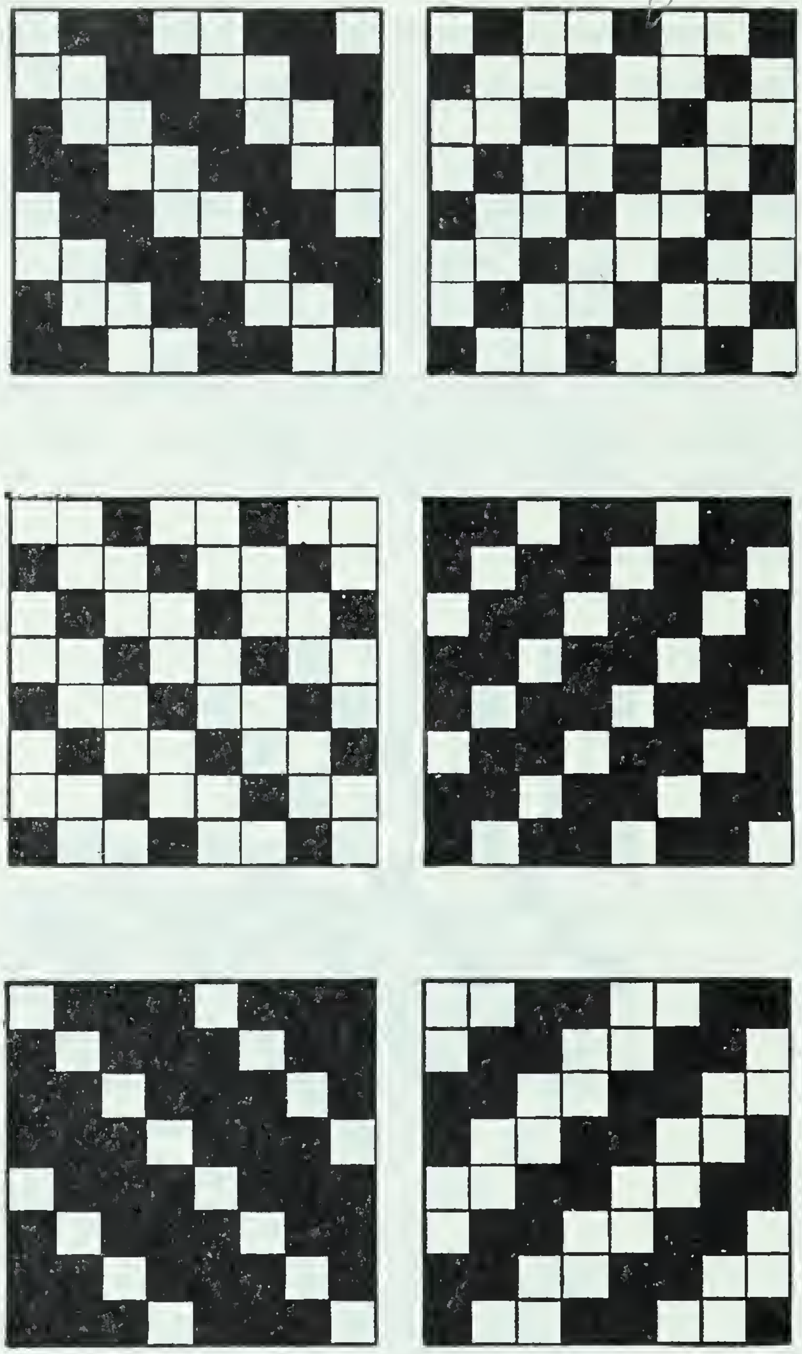


The twill weave gives a distinct design in the form of a diagonal. This drawing shows a three-shaft twill; that is, two warp yarns are interlaced with one filling yarn to form the diagonal.

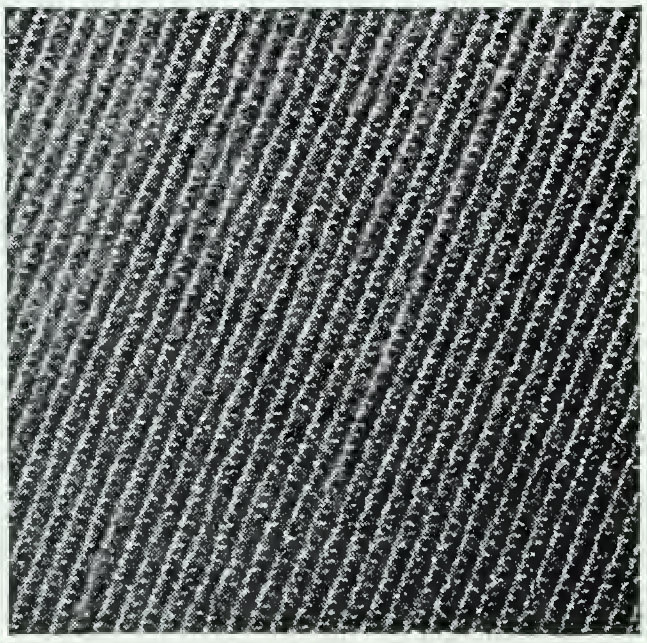
*Fabrics in Ribbed Effects.* Warp-ribbed fabrics are: Bedford cord, piqué, and dimity. Filling-ribbed fabrics are: poplin and rep in cotton; bengaline, grosgrain, poplin, and ottoman in silk or rayon.

**Twill Weave.** A distinct design in the form of diagonals, called *wales,* is characteristic of the second basic weave, called the twill. Changes in the direction of the diagonal lines produce variations, such as the herringbone, corkscrew, entwining, and fancy twills. Increased ornamentation may be obtained by varying the diagonal, but the chief values of the twill weave are its strength, firmness, and drapability. The yarns are usually closely battened, making an especially durable cloth. Twill weaves are therefore commonly used in men's suit and coat fabrics and for work clothes, where strong texture is essential.

In the twill weave, the filling yarn interlaces more than one warp yarn, but never more than four, as strength would be sacrificed by so doing. On each successive line, or pick, the filling yarn moves the design one step to the right or to the left, thus forming the diagonal. Whichever the direction of the diagonal on the face of the cloth, the design runs in the opposite direction on the reverse side.



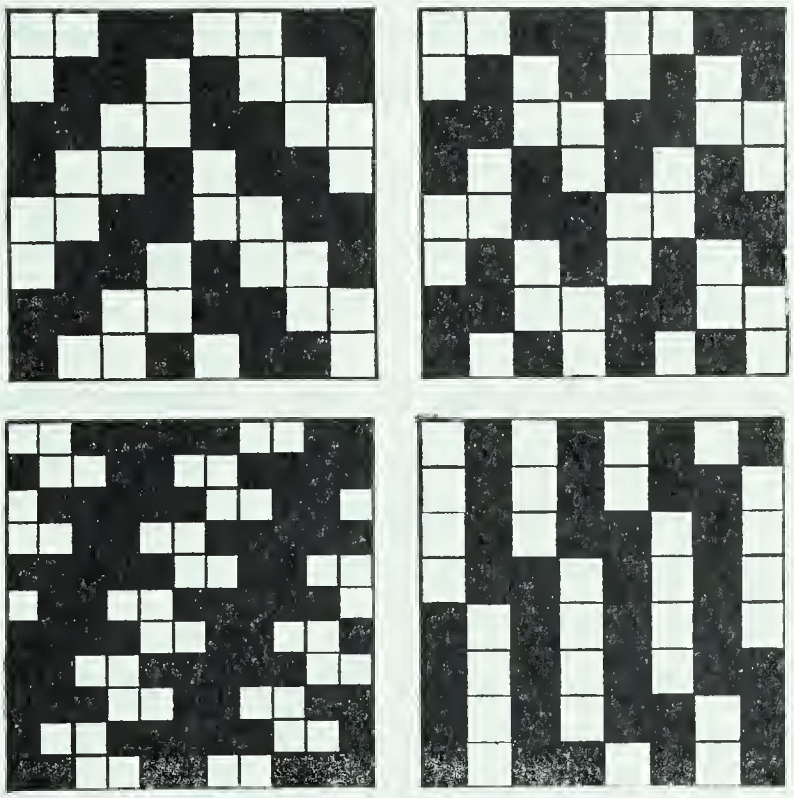
*Above:* The basic diagonal of the twill weave is shown in all these drawings. The direction of the diagonal and the number of harnesses used produce different surface designs. The drawings at the left show left-hand twills; those at the right are right-hand twills.



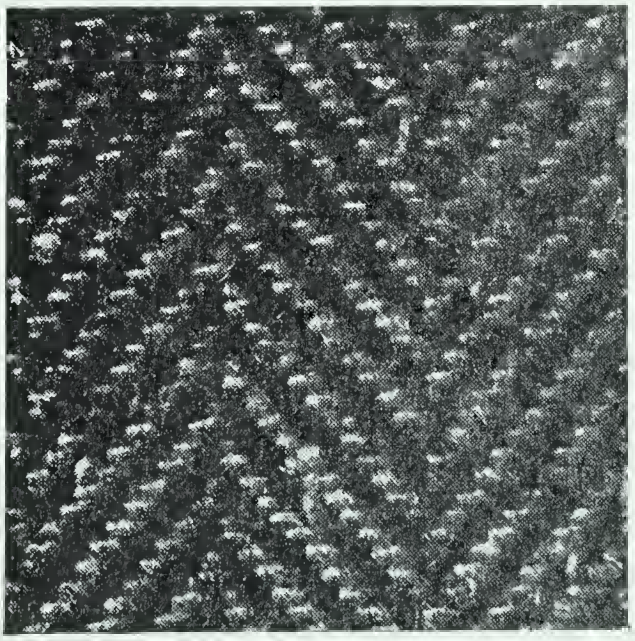
*Left:* The characteristic diagonal of the twill weave can be seen in this sample of a twill fabric.

Twill weaves are named according to the number of harnesses required to make the design. A three- or four-harness twill is a frequently used term. The words "shaft" or "leaf" are sometimes substituted for "harness"; hence the term *three-shaft* or *four-shaft twill.*

Twill weaves are also classified as *even* or *uneven* according to the number of warp and filling yarns that are visible on the face of the cloth. The even twill, for example, shows an equal number of warp and filling yarns in the recurring design, such as two over and two under. This pattern makes what is called a four-shaft twill, and it requires four harnesses.


These variations of the twill weave show broken twills (herringbone) in the two upper drawings, a gabardine in the lower left, and a corkscrew twill in the lower right.

Most twill weaves are uneven. An uneven twill may show more warp than filling yarns in the recurring design; this is called a *warp-effect twill.* If more filling yarns than warp yarns show on the face, the weave is called a *filling-effect twill.* An example of an uneven twill is three and one, or three up and one down, indicating the manner in which the harnesses are lifted and lowered. The result is a warp-effect twill.


The common herringbone twill.

*Fabrics in Twill Weave.* Wool fabrics are usually right-hand twills, as the diagonal lines run from the lower left corner to the upper right. Wool twill-weave fabrics are: broadcloth, cashmere, cheviot, covert, flannel, gabardine, jersey, mackinaw, melton, pilot cloth, serge, tweed, whipcord, worsted cheviot.

Silk fabrics are also right-hand twills. They include foulard, merveilleux, peau de soie, silk serge, and surah.

Cotton fabrics are usually left-hand twills, as the diagonal lines run from the lower right corner to the upper left. They include canton flannel, covert cloth, coutil, denim, drill, gabardine, hickory shirting or hickory stripe, jean, khaki, middle twill, outing flannel, silesia, ticking, venetian cloth, whipcord.

The twill weave is not used much in the production of linen, as linen yarns make a naturally strong fabric. It may be found in linen ticking, twill toweling, and towel drills.

**Satin Weave.** In basic construction, the satin weave is similar to the twill weave; but the diagonal of the satin weave is not visible because it is purposely interrupted. A continuous diagonal would interfere with the luster and smoothness that are the desired qualities of the satin weave.

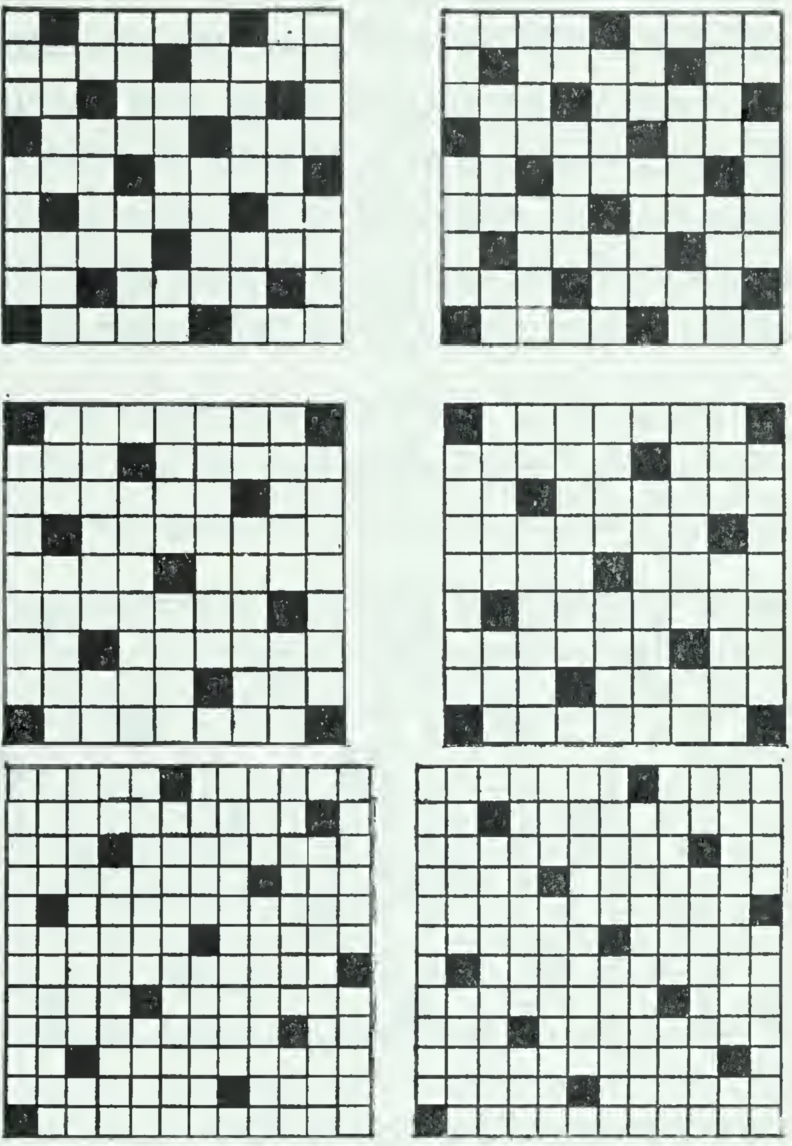
The satin weave employs a minimum of five harnesses because a smaller number would simply result in forming a twill weave. The use of five harnesses produces a five-shaft construction; that is, the filling yarn passes under one warp yarn and over four warp yarns. The yarn advances more than one warp yarn on each pick, thus interrupting the diagonal. When more harnesses are used, more warp yarns are interlaced by the filling yarn. The number may run as high as eleven, making what is termed a twelve-shaft construction because one filling yarn interlaces eleven warp yarns.

No surface design is visible on satin fabric because the yarns that are to be thrown to the surface are greater in number and finer in count than the yarns that form the undersurface of the cloth.

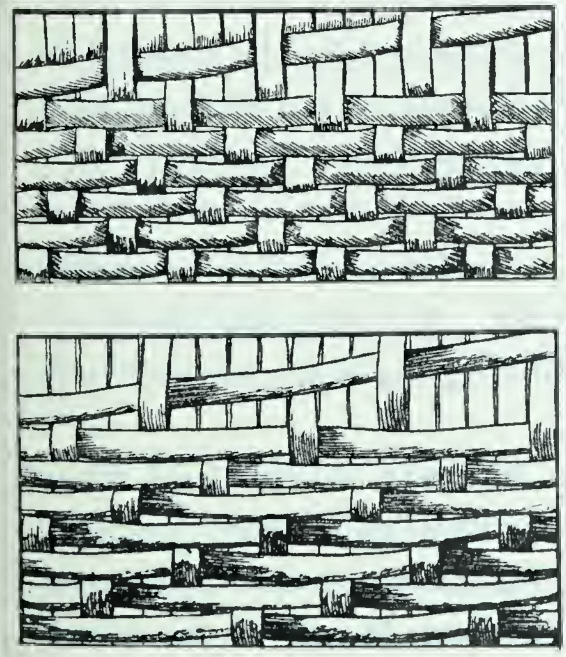
*Floating Yarns.* Because the interlacing yarn passes over more yarns than it passes under, long yarns, called *floats,* are exposed on the surface of the cloth. Reflection of light on the floats gives satin fabric its characteristic luster, which is the primary object of the satin weave. When the floats are in the warp, the satin weave produces a warp-faced fabric, and the luster appears in the direction of the warp. When the manner of interlacing is reversed so that the filling yarns are thrown to the surface, a filling-faced fabric is produced; and the luster appears in the direction of the filling. This variation is known as the *sateen weave.*

Sateen is also the name given to a cotton fabric that has floating yarns in either warp or filling.

The long floats found in the satin weave might be called a disadvantage as they represent a minimum of interlacings, and therefore a potential weakness in the fabric. The longer the float, the greater the chance that the surface of the fabric will snag, roughen, and show signs of wear. On the other hand, the long float gives satin



*Above:* The two top drawings show a five-shaft satin construction; center drawings an eight-shaft construction; lower drawings a twelve-shaft construction.



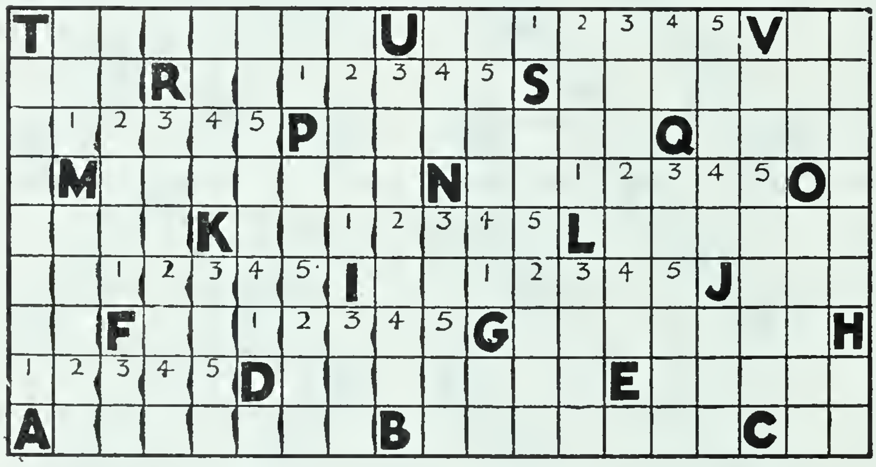
*Left:* These drawings show long float yarns in the filling, typical of the sateen weave. The upper drawing is a five-shaft construction; the lower an eight-shaft construction.

fabric its desired luster and smoothness. The luster makes the fabric suitable for dressy wear; and the smoothness, for use as lining.

Satin-weave fabrics drape well because the weave is heavier than the twill weave, which, in turn, is heavier than the plain weave. More harnesses are employed in the satin weave, thus compressing a greater amount of fine yarn into a given space of cloth. The quality of drapability makes satin fabrics preferable for evening dresses.

*Designing a Satin Construction.* When making a design for a satin construction, the interlacings on successive lines must be separated by a proper interval to avoid forming the contiguous diagonal. When the proper interval for any shaft construction is selected, the design will not repeat itself until the number of successive picks that make up the desired shaft have been interlaced.

In a five-shaft construction, for example, the design begins to repeat on the sixth line; in an eight-shaft, on the ninth line; in a twelve-shaft, on the thirteenth line.



This drawing illustrates the eight-shaft sateen construction explained in the text. Each of the horizontal lines of blocks represents a filling yarn, or pick. The blocks covered by letters are the points at which the filling yarns interlace the warp yarns on each successive pick.

An eight-shaft satin construction is explained here in order to illustrate the basic rules that must be followed to select a suitable interval.

1. Arrange in pairs the numbers that will add up to the desired shaft number. For an eight-shaft satin, the shaft number is 8. The pairs are: 1 and 7, 2 and 6, 3 and 5, 4 and 4.

2. Eliminate the pair that contains the number 1 and the number below the shaft number, which is 7 in this case. A contiguous diagonal would result if these intervals were used, producing the conventional twill weave.

3. Next, eliminate the pairs that have a common divisor and those that are divisible into the shaft number. This step eliminates 2 and 6, 4 and 4. The pair, 3 and 5, remains. These numbers are the only intervals that can be used in an eight-shaft construction. If any of the elimi-

nated numbers were used as an interval, the cloth would show no interlacing whatever for one or more warp yarns; in fact, there would be no cloth, as it would fall apart.

Now that the only possible interlacings have been worked out, the design can be constructed. (See the accompanying drawing.) For convenience, here the interlacing begins in the lower left square, at *A*. The horizontal rows of squares represent filling yarns—that is, the successive picks on the loom. The vertical rows represent the warp yarns.

The interval to be used for this particular design could be 3 or 5; in this case, 5 has been selected. As this is to be an eight-shaft construction, the interlacing on the first pick will be 7 squares (warp yarns) apart at *B* and *C*.

To find the warp yarn that will interlace on the second pick, count 5 to the right, beginning with the square above the interlacing that is already started at *A*; thus, the interlacing occurs at *D*. Adjacent interlacing on the same line will be 7 squares apart, at *E*.

To find the warp yarn that will interlace on the third pick, start with the square above *D*. Count 5 to the right, and interlacing *G* is plotted. Adjacent interlacings will be 7 squares apart.

On the fourth pick, interlacing *I* is found by counting 5 to the right of the square above *F*; *J* is found by counting 5 to the right of the square above *G* (or 7 squares from *I*).

This same procedure determines the interlacing points on successive picks, additional interlacings always being 7 squares apart.

On the ninth pick, the design starts to repeat, which proves the accuracy of the construction of an eight-shaft weave.

Where it is not possible to plot subsequent interlacing by continuing to count to the right, because of the small area of the design, interlacings on successive picks can be determined by counting 3 to the left instead of 5 to the right. If the interval 3 had been used to count to the right, 5 would have been used to count to the left.

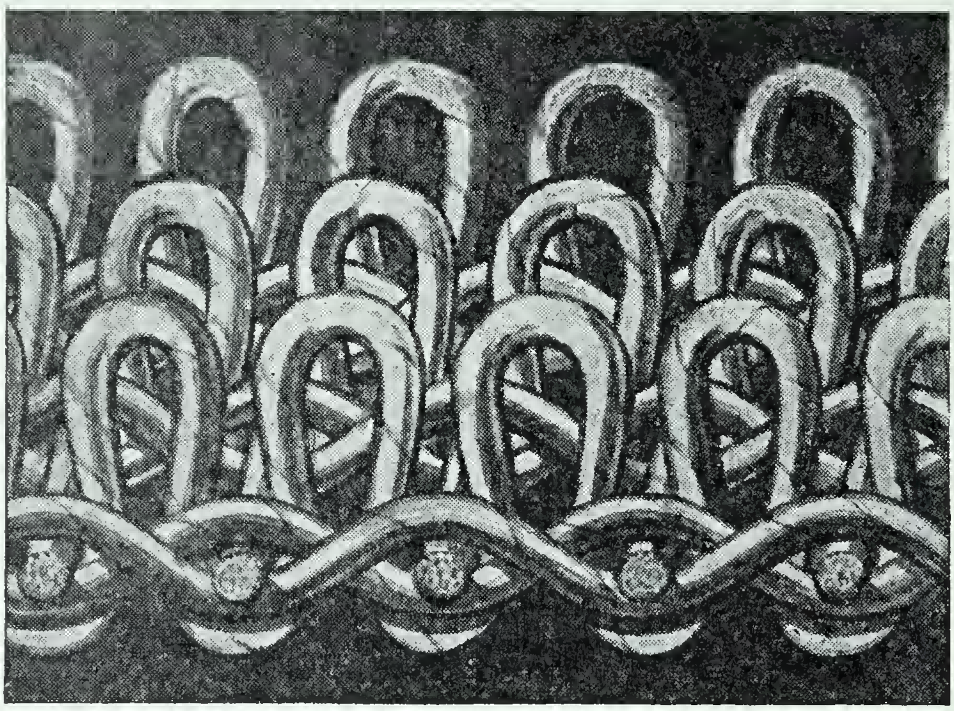
*Fabrics in Satin Weave.* In silk or rayon: baronette satin, charmeuse, damask, duchesse, messaline, peau de soie, satin, satin crepe, panne satin.

In cotton: damask, lustrine, sateen, ticking, venetian cloth.

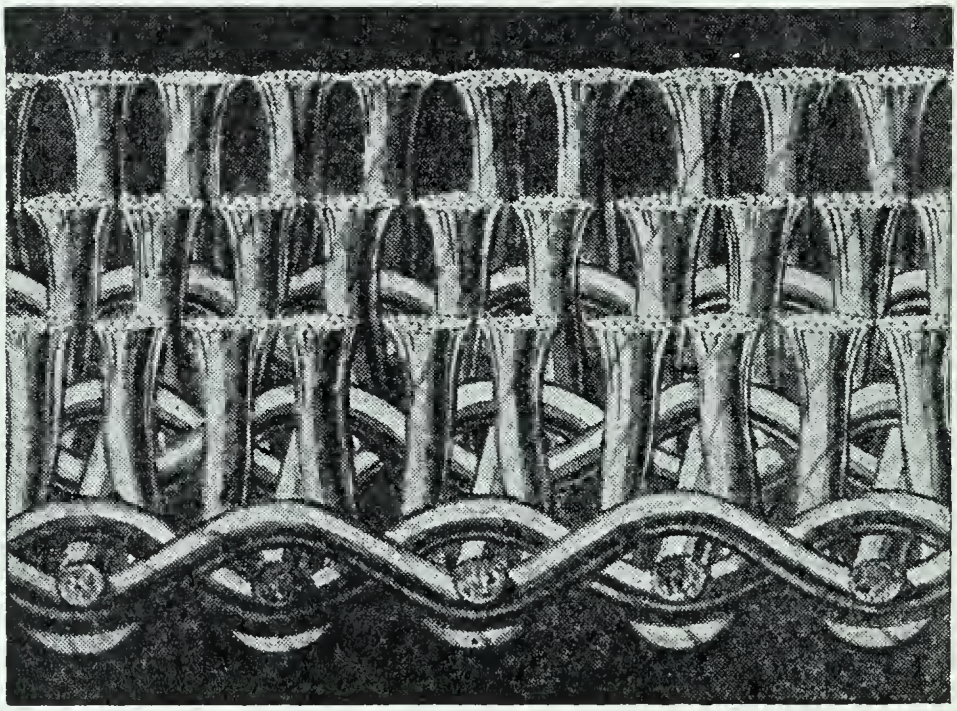
In linen: single and double damask.

**Pile Weave.** The pile weave is a fancy weave that also includes a plain or a twill construction. In contrast to the three basic weaves that produce a flat surface on a fabric, the pile weave introduces a decorative third dimension, creating an effect of depth. Its construction is especially desirable where softness, warmth, and absorbency are desired.

Pile-weave fabrics are also durable if the proper yarns and adequate, compact construction are used. In the manufacture of rugs, for example, a strong, tightly twisted staple with compact construction in the base cloth will withstand long wear.



*Left:* This drawing shows the pile weave as it looks after the wires that have raised the filling yarns have been withdrawn.



*Right:* Cut pile, similar to that shown in this drawing, can be produced by using wires equipped with razorlike ends that cut the loops as the wires are withdrawn.

The pile is produced by weaving an additional warp yarn or filling yarn into the basic structure. The additional yarn is drawn away from the surface of the cloth by thick wires, which form loops at regular intervals. These loops may be cut or closely sheared, or left uncut if a loop surface is desired, as in Brussels carpet.

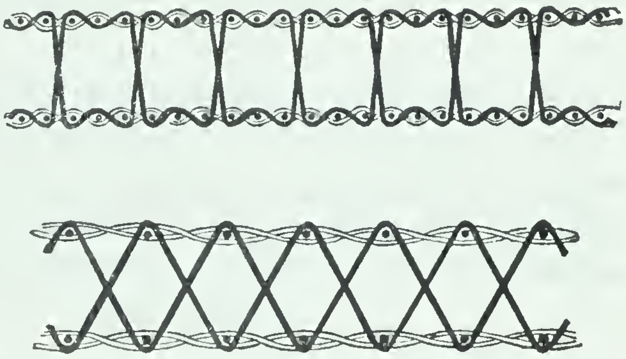
When the pile is produced by an extra warp yarn, the result is a warp-pile fabric, of which terry, carpet, and plush are examples. Fabrics are classified as *plush* when the pile is more than 1/8 inch high.

When the pile is produced by an extra filling yarn, the result is a filling-pile fabric, of which velveteen and corduroy are examples.

In certain cut-pile fabrics, the wires used to form the loops are equipped with razorlike ends so that the loops are cut when the wires are withdrawn, thus producing the cut pile exemplified by broadloom carpet.

Cut-pile fabrics are produced economically by constructing double-cloth fabrics, as explained in the following section; then cutting the two cloths apart.

Pile effects can also be created by using varying tension in the warp yarns. In the manufacture of rugs, such as chenille, Wilton, velvet, and tapestry, various processes are used for pile effects, including hand knotting.



The double-cloth weave can be produced by either of the two methods shown here: the V method in the upper drawing, and the W method in the lower. Cutting the yarn that holds the two cloths together makes two separate cut-pile fabrics.

*Fabrics in Pile Weave.* In cotton: chenille, corduroy, duvetyn, frieze, plush, terry (turkish toweling), velour, velveteen.

In wool: frieze, plush, velour, rugs of all kinds.

In silk or rayon: chenille, frieze, fur fabrics, plush, transparent velvet, velour, velvets of all kinds.

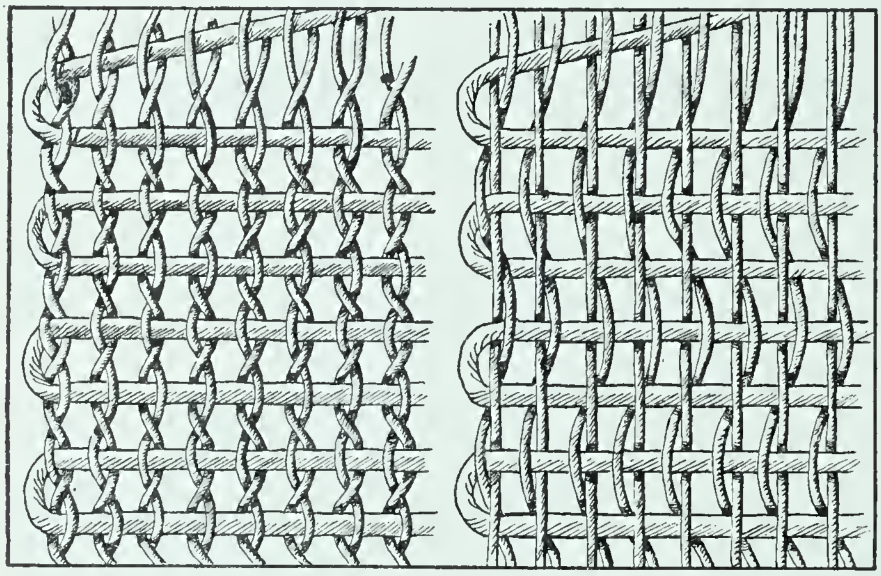
Linen is seldom made in the pile weave.

**Double-Cloth Weave.** In the double-cloth weave, two cloths are woven on the loom at the same time, one on top of the other. The fabric may have a plain weave on one side and a twill weave on the other. Each of the cloths requires its separate sets of warp and filling yarns. The cloths are combined by interlacing some of the warp or filling yarns, or they may be combined by means of a complete fifth set of stitching yarns.

The surfaces of such fabrics may show different patterns or color on each side by varying the yarns as to color and size. A true double-cloth weave is never a pasted construction.

Because the double-cloth weave produces two pieces of cloth combined into one, fabrics so woven are commonly regarded as strong and warm. Warmth, however, is due primarily to the insulative properties inherent in a fiber; bulk and thickness alone do not give warmth. Also, strength cannot be judged by mere thickness or weight. It cannot be assumed that a double-cloth weave will have the qualities of warmth and strength; on the contrary, the fabric may be heavy, bulky, and needlessly expensive.

Sometimes this method of construction is chosen in order to use a cheaper material on the reverse side of the cloth, thus reducing the cost of a heavy fabric.



The gauze weave is shown at the left, the leno weave at the right. Note how the filling yarns in the gauze weave are encircled by two warp yarns twisting around each other, a construction that gives strength although the mesh is open. In the leno weave, the second of each two warp yarns merely passes around the first yarn.

*Fabrics in Double-Cloth Weave.* In cotton: double-faced blankets, bathrobe blankets.

In wool: polo cloth, steamer rugs, overcoatings.

In silk: upholstery fabrics of all kinds.

**Gauze Weave.** The gauze weave must not be confused with the weave used in manufacturing gauze bandages or cheesecloth; these materials are made with the plain weave. The gauze-weave type of construction produces a fabric very light in weight and with an open-mesh effect. Curtain materials and some cotton dress goods are woven with this weave. Such lightweight fabrics have a strength that could not be provided by the plain weave. In the gauze weave, strength is obtained by the manner in which the yarns are intertwisted: each filling yarn is encircled by two warp yarns that are twisted about each other.

The gauze weave is sometimes referred to as the *leno weave* because it is made on a leno loom, but the true leno weave is merely a variation of the gauze weave. On the leno loom, the action of one warp yarn is similar to the action of the warp in the plain weave. A second warp yarn passes around the first warp simultaneously and alternately over and under the filling yarn. The leno is sometimes used in combination with the plain weave in order to produce a stripe or figure on a plain background. Generally, the term "leno" is used synonymously with "gauze."

*Fabrics in Gauze Weave.* In cotton: grenadine, marquisette, mosquito netting, rice net, mesh shirtings.

In silk or rayon: bolting cloth, curtain madras, grenadine, marquisette.

**Swivel Weave.** The swivel weave is the method by which decorative effects, such as dots, circles, or other figures, are interwoven on the surface of a fabric while the cloth is being constructed on the loom. The weaving of the design requires an extra filling yarn and additional small shuttles. A separate shed is made for these shuttles.

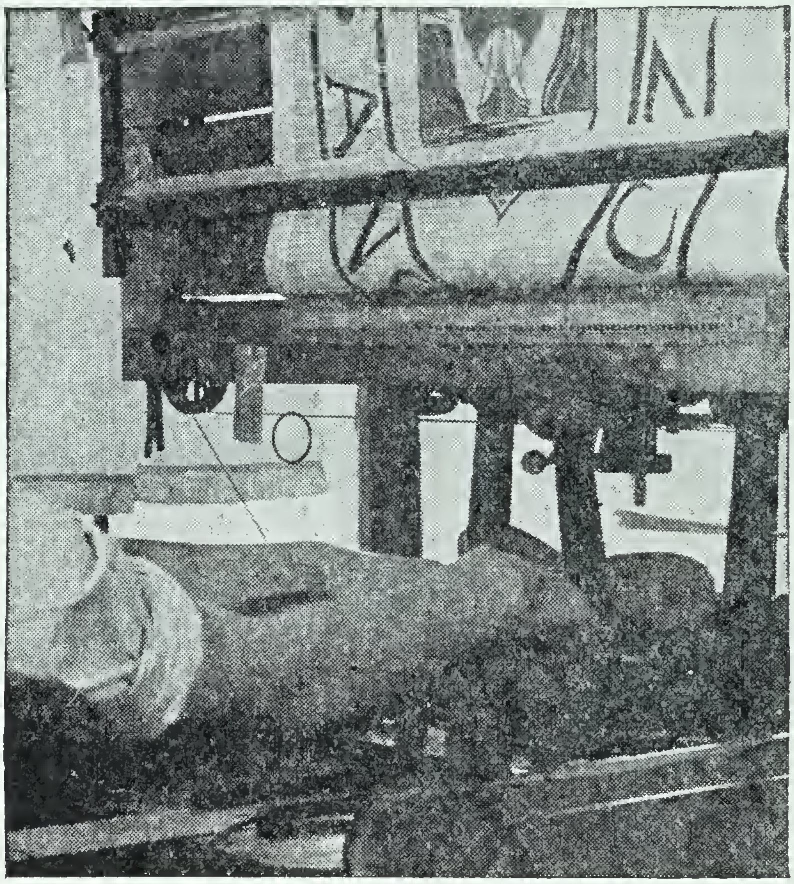
While the cloth is being constructed, the row of small shuttles drops across the width of the loom, and each shuttle interweaves its separate design with a circular motion on a small area of the warp. A long thread is carried on the undersurface of the cloth from one design to the next. Different colors may be used in each of the designs because each figure is woven by its own shuttle containing its own miniature bobbin.

The decoration produced by the swivel weave is not considered durable because the swivel yarns are cut when the cloth is completed and cannot be securely fastened. The cut ends roughen the undersurface of the cloth and may pull out if the fabric is handled carelessly in laundering.

*Fabrics in Swivel Weave:* dotted swiss, grenadine, curtain madras.

**Lappet Weave.** The lappet weave is also used to superimpose a small design on the surface of a fabric while the cloth is being woven. In the lappet weave the design is stitched into the fabric by needles that operate at right angles to the construction. Thus, the lappet weave is very similar to embroidery.

The lappet design is made with one continuous additional warp yarn, which is carried on the back of the cloth from one design to the next. Only one color is possible. Although the floating threads on the back are cut away when the cloth is completed, the ends are fastened securely and will not pull out easily.



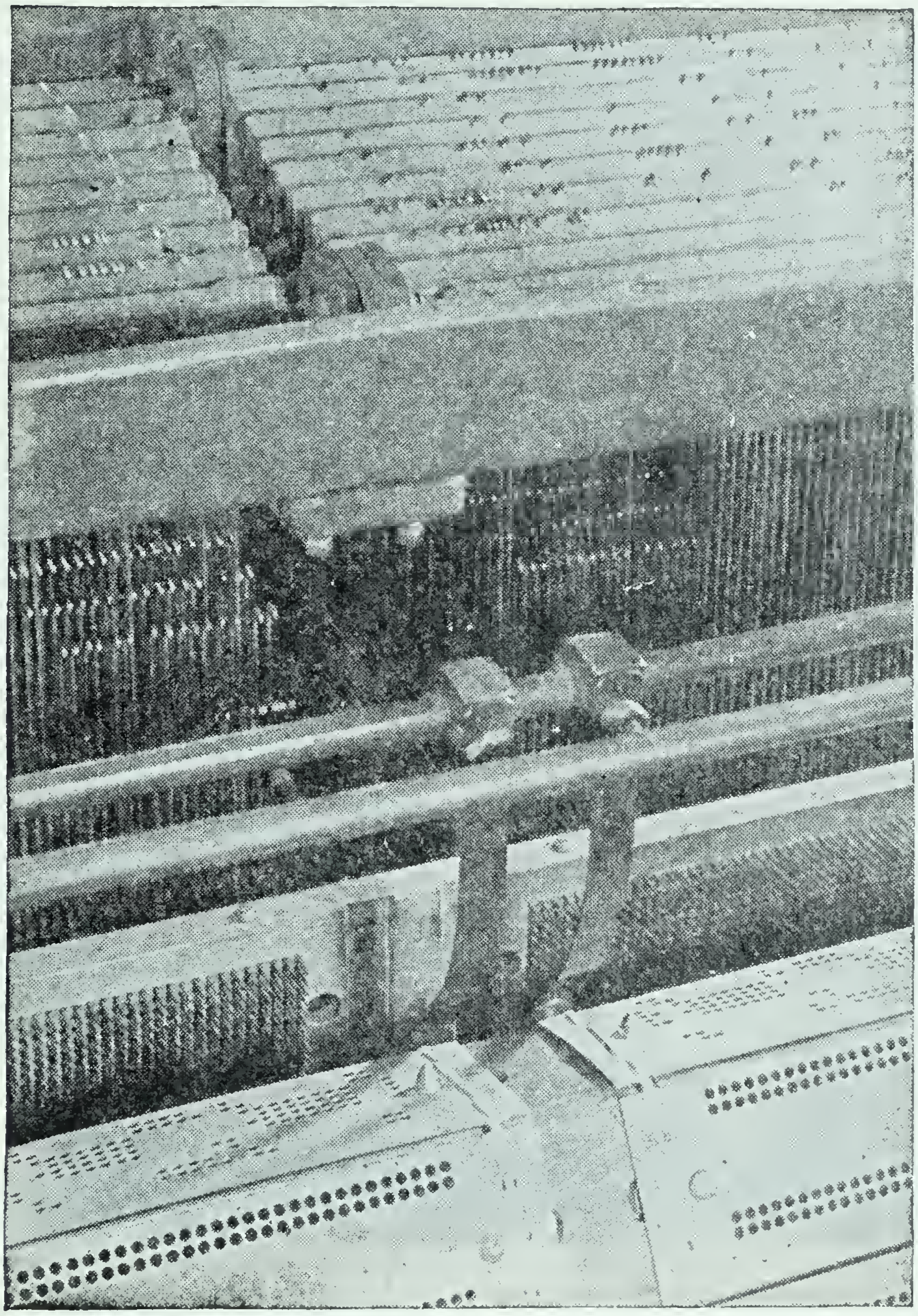
The design shown at the upper part of this picture is being transferred to Jacquard cards (lower left) by punching holes in the cards corresponding to the design. Filling yarns will be raised through the perforations by the loom mechanism.

*Fabric in the Lappet Weave.* Dotted swiss produced by the lappet weave is superior to swivel-weave dotted swiss.

**Dobby Weave.** The dobby weave is a patterned weave used to construct designs that cannot be produced by the plain, twill, or satin weaves. The designs are simple, limited in size, and usually geometric in form. They are found in shirtings and tie fabrics.

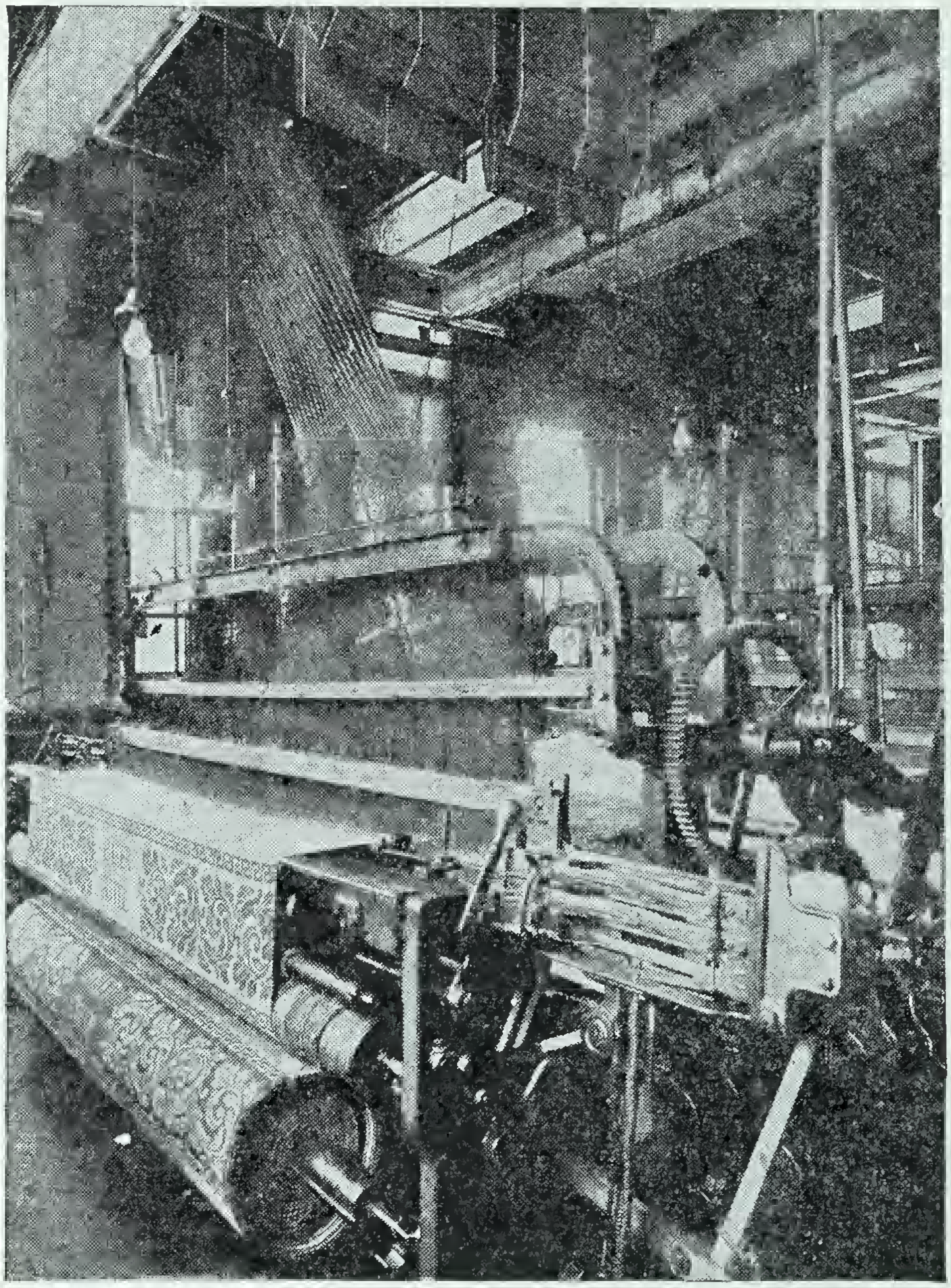
The dobby weave is created on a plain loom by means of a mechanical attachment called a dobby or cam, which raises or lowers as many as twenty-four to forty harnesses containing the series of warp yarns that form the pattern. Although a large number of harnesses is used in this construction, the design is always small and does not make use of long floats. The most familiar type of dobby weave is bird's-eye, the small diamond pattern that has an eye in its center.

***Fabrics in Dobby Weave.*** In cotton: bird's-eye, huckaback.
In linen: cretonne, huckaback, mummy cloth.
In wool: granite cloth.



Here is a close-up of Jacquard cards laced together as they appear on the mechanism at the top of the loom. As the cards move, needles behind the cards drop through the perforations and lift strings, which, in turn, lift heddles.

**Jacquard Weave.** In any of the weaves that have been described, the number of harnesses determines the construction. For example, two harnesses are required for the plain weave, three or more for the twill, and five to twelve for the satin weave. As many as forty can be manipulated by the special attachment of the dobby. The dobby designs are not intricate, however. They are limited to straight lines, edges, steps, or very small circular lines.

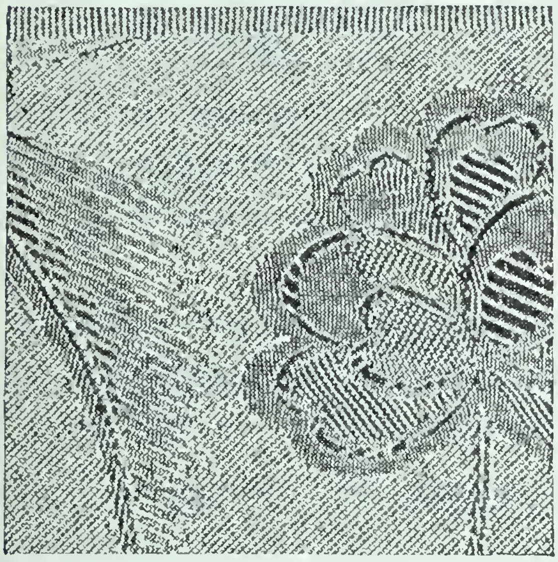


This complete picture of the Jacquard in operation shows the laced cards at the top of the loom. The long, slanting strings control the heddles immediately below the cards. The heddles raise and lower the warp yarns in accordance with the pattern punched on the cards above, the filling yarn making the design as the shuttle passes across the loom.

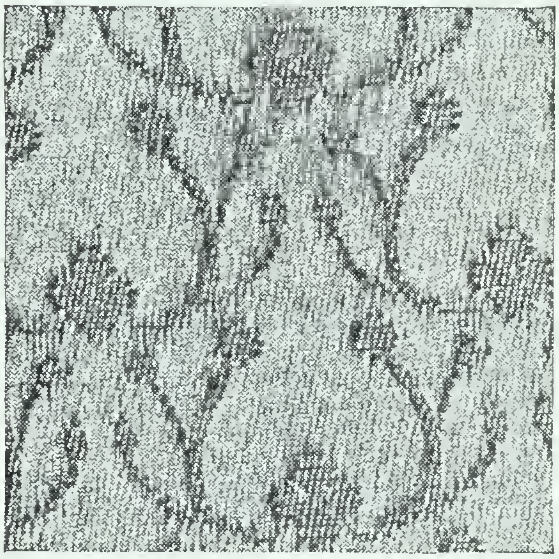
For curves, swirls, and large-sized figures, it was necessary to devise a different mechanism that would allow an unlimited range of intricate designs. This need is met by the Jacquard attachment, named after its inventor, Joseph Marie Jacquard, a Frenchman.

The Jacquard mechanism controls thousands of heddles, which lift one or more warp yarns independently of others without the use of harnesses. Its action may be likened to the action of the player piano, where each note is governed by a hole on the music roll and is sounded when the hole passes over a certain opening.

The Jacquard design is first worked out on squared paper. Cards are then perforated to correspond with the design; they are laced together and placed on the Jacquard attachment. The moving cards pass over a battery of needles mounted on top of the loom. Each needle controls a string, which when released picks up the heddle to which it is tied. The perforations on the cards allow the needles to drop through, and lift certain strings, which, in turn, lift single heddles independently of others.



Damask produced by the Jacquard.



Brocade produced by the Jacquard.

The preparation of a Jacquard weave is the most expensive part of its construction. Setting up the loom may take several weeks or months; but once set, the pattern to be produced can be used and reused for different materials. As Jacquard weaving is the most expensive form of weaving, it is chiefly used for linen and silk fabrics and for such upholstery materials as damask, brocade, brocatelle, and tapestry.

Floats are inevitable in the Jacquard weave because of the elaborate designs. As in the satin weave, long floats may affect the wearing quality of the fabric; also, long cotton yarns exposed to friction

### SUMMARY OF BASIC WEAVES

| Weave | Characteristics | Advantages | Limitations |
|---|---|---|---|
| PLAIN | No distinct design unless yarns have contrasting colors | Maximum yardage; easily produced; inexpensive; strong; adaptable for direct printing and other finishing processes | Sleazy fabric if cloth count is low |
| *a.* BASKET | Basket pattern | Attractive; inexpensive | Not durable for apparel |
| *b.* RIBBED | Corded effects | Ornamental | Not serviceable if of inferior construction |
| TWILL | Distinct diagonal design | Strong, firm texture; increased drapability; interesting designs | Requires care to keep clean |
| SATIN | Luster; interrupted diagonal design discernible only with magnifying glass | Beauty contributed by luster; smoothness; maximum drapability | Excessively long floats may snag and roughen fabric |

cause lint. Compact construction of the cloth, however, offsets the tendency to friction and wear; therefore, the consumer should select the better-quality fabrics when purchasing those having the Jacquard weave. This is especially necessary when purchasing linen damask because table linens receive hard wear and repeated washings.

*Fabrics in Jacquard Weave.* In cotton: matelassé, damask, tapestry.
In linen: single and double damask.
In wool: tapestry.
In silk or rayon: brocade, brocatelle, damask, and tapestry.

**Distinguishing Warp and Filling.** A person who handles fabrics must be able to identify the warp and the filling yarns in a piece of cloth, for the direction of the warp determines the way in which cloth should be cut when garments are made from it.

In a new piece of yard goods, the direction of the warp is easily distinguished. The length of the fabric indicates the warp yarns. Also, if a piece of material shows a bit of the selvage, the firm edge of the cloth, then the yarns parallel to the selvage are manifestly warp yarns. The opposite set of yarns are the filling yarns.

When a sample of fabric contains no selvage, the warp and filling may be identified by observation of the weave.

1. In plain weaves, a greater number of yarns running in one direction indicates the warp.
2. In twill weaves, the filling yarns run in the direction of the diagonal, which may be toward the right or toward the left.
3. In satin weaves, the floating yarns are the warp yarns.

When the name of the fabric is known, its characteristic features aid in distinguishing the warp and filling. For example, the ribs of dimity and of piqué run in the direction of the warp; the ribs of rep, faille, bengaline, and poplin, in the direction of the filling. When colored stripes show in such materials as chambray, madras shirtings, and in some dress goods, the direction in which the stripe runs usually indicates the warp.

When the warp and the filling cannot be identified by any of the foregoing aids, the sets of yarns may be examined for some of the following characteristics.

1. Exerting tension on a sample by holding it in both hands and pulling, at the same time pressing with the thumbs and forefingers, will show which set of yarns is stronger. The stronger set will be the warp, because warp yarns have to withstand the tension of the heddles in the weaving process. The filling yarn, which emerges from the bobbin of the shuttle as it crosses the fabric, is under little tension.
2. When one set contains yarns of varying sizes, this set is usually the warp. Filling yarns are usually of the same size.
3. The set of yarns that can be more easily stretched is the filling.

4. Yarns of inferior quality are commonly used as filling in inexpensive fabrics. When both sets of yarns are carefully compared, the inferior yarn is usually the filling.
5. When a yarn has a hard twist, as in serges and overcoatings, that yarn is generally the warp yarn.
6. Yarns with slack twist usually are the filling yarns, because yarns with little twist are used as filling when a soft and lustrous effect is desired.
7. If one set consists of thicker yarns, this indicates the filling, as the bulk produced by large-sized yarns dispenses with the need for a great amount of twist.
8. If ply yarns are used they probably indicate the warp.
9. In a napped fabric, the warp runs in the direction of the napping, because the fabric has been run through the machine in the direction of its length.
10. In light cotton or silk fabrics, a marked evenness between the yarns indicates the warp. This evenness is the result of the mechanical movement of the reed as it battens the filling yarns when the cloth is being constructed. In patterned weaves, such as a herringbone twill, the impact of the battening operation leaves small reed marks that distinguish filling from warp yarns.

*Test yourself on this chapter by answering these questions:*

1. Explain why lappet ornamentation is permanent and swivel is not.
2. Why are harnesses not required in the Jacquard weave?
3. Construct a design for one variation of the plain weave.
4. Construct a design for a twill weave.
5. Construct a design for producing a ribbed effect in the warp.

6. Describe the basic operations of the weaving process, naming specific parts of the loom.

7. Compare the pile weave and its uses with the double-cloth weave and its uses.

8. Differentiate between plain weave, ribbed weave, basket weave, and twill. Explain how each is made.

9. Discuss the comparative advantages and disadvantages of the twill and the satin weave. Give an example of a fabric for each.

10. Which of the three basic weaves is: (*a*) The most durable? Why? (*b*) The most beautiful? Why? (*c*) The most inexpensive to produce? Why?

11. What weave would you prefer in a skirt, a suit, curtains?

12. Is it of any advantage to the consumer to know the basic differences between the three foundation weaves? Why?

13. Why was the Jacquard weave somewhat revolutionary in the weaving industry?

14. Contrary to common belief, why does the gauze weave embody strength?

15. How can you differentiate between damask and a fabric made by the dobby weave?

## Suggested Readings

Dooley, W. H., *Textiles,* Chapter 7.
Dyer, E., *Textile Fabrics,* Chapter 5.
Hess, K. P., *Textile Fibers and Their Use,* Chapter 1, Section 1.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 3.
Small, C. P., *How to Know Textiles,* Chapters 3, 7.
Wingate, I. B., *Textile Fabrics,* Chapters 9, 10.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapters 3, 4.

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# CHAPTER V

# FINISHING: APPEARANCE AND SERVICEABILITY

Newly constructed cloth as it comes from the loom does not represent finished consumers' goods. It must pass through various finishing processes that make it suitable for many different purposes. Finishing enhances the appearance of the cloth and also adds to its serviceability and durability, thus increasing its value. Familiarity with finishing processes enables the consumer to recognize and judge quality in fabrics.

The untrained purchaser is influenced too readily by quantity rather than by quality. He is apt to choose the large, the bulky, the heavy. As manufacturers and retailers conduct their businesses to meet existing demand, textile fabrics are finished to a large extent to satisfy this type of purchaser. This explains why many fabrics are "oversized" and others are weighted. If cloth is not properly constructed and if finishing processes are used to conceal inferior construction or to simulate superior quality, the durability of the finished product is questionable.

But this does not mean that all finishing is intended to deceive the consumer, for no type of finish should be labeled as spurious until the purpose of the fabric has been considered. The fact that there is a sustained demand for a particular kind of finished cloth usually explains its continued production.

**Converting Gray Goods.** Finishing processes have assumed such great importance in the textile industry that this phase of textile manufacturing is undertaken by a highly specialized group of middlemen called *converters.* Conversion of *gray goods,* or goods *in the gray,* includes the various types of finishing processes as well as subsequent dyeing and printing.

The converter contracts for a volume purchase of gray goods and converts this unfinished product into finished consumers' goods in accordance with either solicited demand, based on orders taken by his selling force, or with anticipated demand, which is an estimate of the immediate market.

The term *greige goods,* which was originally applied only to unfinished silk fabrics, is also used to denote any undyed, unfinished cloth as it comes from the loom.

**Kinds of Finishing Processes.** Finishing may take many forms, for it must be adapted to the kind of fiber and yarn used in the fabric and, most important of all, to the intended purpose of the fabric. One type of gray goods may emerge from a certain finishing process in a form suitable for curtains, while the identical gray goods put through other finishing processes can be used for dress material.

Even the factor of cloth count, so important in the evaluation of a fabric, can be changed by the kind and amount of finishing. Cotton can be given the soft finish required for such fabrics as batiste, nainsook, and lawn; the napped finish required for flannelette and duvetyn; the hard, stiffened finish typical of cambric and linene; or the lustrous effect of chintz.

The most common finishing processes are listed here; but the list does not represent a sequence, nor are all the processes mentioned applicable to all kinds of gray goods. Some fabrics must be put through more than one process; some of the first-named operations constitute essential preparatory processing for other final finishes. Cotton, linen, wool, silk, rayon—each must be given its own characteristic finishes.

1. Singeing or gassing
2. Bleaching
3. Mercerizing
4. Shrinking
5. Fulling
6. Tentering
7. Crabbing
8. Sizing or dressing
9. Weighting
10. Calendering
11. Schreinerizing
12. Moiréeing
13. Beetling
14. Napping
15. Shearing
16. Crepe and crinkled effects
17. Crease resistance
18. Waterproofing
19. Water repellency
20. Fireproofing
21. Mothproofing
22. Mildewproofing
23. Slip resistance
24. Antiseptic finishes

**Singeing or Gassing.** If a fabric is to have a smooth finish, singeing is one of the first essential preparatory processes. It burns off lint and threads, as well as all fuzz and fiber ends, leaving an even surface, which is particularly necessary when a cloth is to pass through the mercerizing process or any printing operation.

Singeing is accomplished by passing gray goods rapidly over rows of gas flames or electrically heated plates—at a speed of 100 to 250 yards a minute. After singeing, in the case of cotton fabrics, the cloth is given a bath and is then steeped for several hours in large boiling vats, called kiers, which contain caustic soda, soda ash, and lime. Thorough circulation of these cleansing agents prepares the cloth for the subsequent bleaching operation.

All kinds of fabrics made of short-staple yarns are singed. Singeing may also be done in the yarn stage; for example, lisle yarn, which is made of highly twisted fine cotton staple, is always singed in order to obtain its characteristic smooth surface.

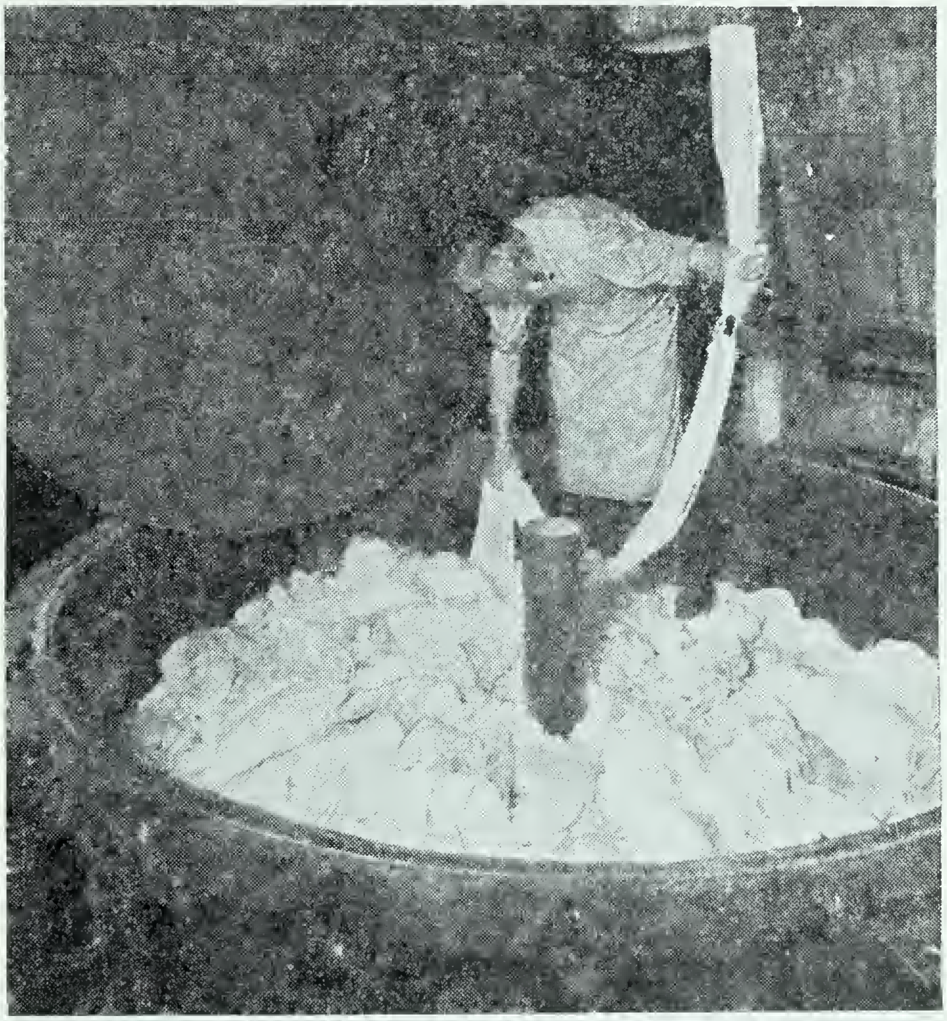
**Bleaching.** If cloth is to be finished white or is to be given surface ornamentation, all natural color must be removed by bleaching. This is also necessary if discoloration or stains have occurred during the previous manufacturing processes. Bleaching can be done in the yarn stage as well as in the cloth. The kind of chemicals to be used depends on whether the fabric or the yarn is composed of vegetable or of animal fibers. When cloth has been bleached for finishing, it is called *bleached goods.*

Cotton or linen fabrics may be bleached by washing only, with subsequent exposure to the sun. Some of the finest Irish linens are bleached in this manner. The slowness of the method eliminates any possibility of overbleaching, which causes deterioration in fabrics.

Chemicals bleach fabrics more quickly than sunshine does; but chemical bleaching requires the utmost care, as too much penetration of the bleaching agent weakens or even decomposes the fibers.

As the use of any strong bleaching agent eventually causes weakness in a fabric, the consumer should select unbleached goods when extreme whiteness is not essential. As there is a general preference for fully bleached white goods, however, additional bleaching is necessary as part of the laundering job; otherwise, white goods eventually take on an unattractive yellowish tinge. If colored goods are selected when possible—for example, in men's underwear—no bleaching is required in laundering, and the garments will consequently last longer.

*Bleaching Cotton and Linen.* Oxidizing agents, such as chlorinated lime or hypochloric acid, are used for bleaching cotton and linen, the vegetable fibers. A similar bleach can be obtained by diluting a concentrated solution of sodium hypochlorite, which is better known to the consumer as Clorox. Chlorine is an oxidizing agent that bleaches coloring matter in vegetable fibers; but as it is a strong chemical, it also weakens the fabric. Thorough rinsing after immersion in the bleaching agent is therefore imperative.

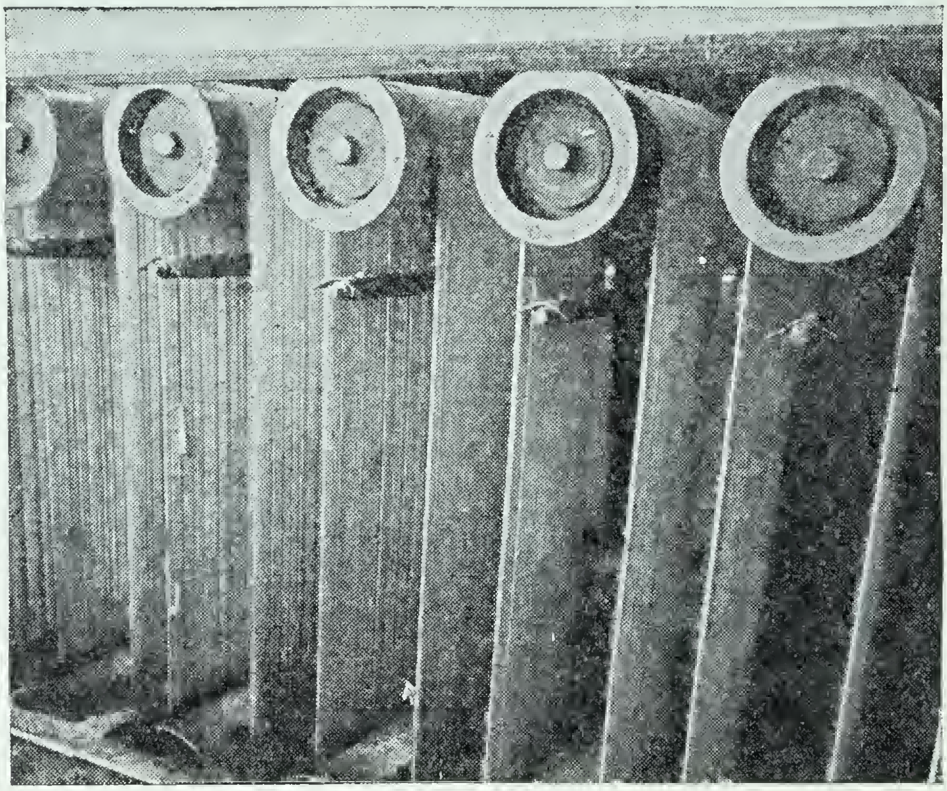


Many hanks of yarn are being placed in a huge iron kier where bleaching takes place.

The commercial preparation known as Javelle water can also be used for bleaching cotton or linen. Javelle water can be prepared by mixing ½ pound of washing soda (sodium carbonate) in 1 quart of cold water, adding ¼ pound of chloride of lime. The liquid should be strained through a piece of cloth before using.

Commercial bleaching of cotton and linen fabrics is essentially the same in principle. Gray goods are passed through chlorinated lime or hypochloric acid. The material is then put through a mangle and placed in bleaching bins, where it remains from two to twelve hours, depending on the strength of the bleaching agent and the material. To neutralize the action of the bleach, a mild solution of sulphuric acid is used afterward. The cloth is then rinsed in clear water and dried.

*Bleaching Wool and Silk.* For silk and wool, oxidizers cannot be used as they injure animal fibers. White silk and white wool fabrics do not remain white long because exposure to light and air brings back the natural discolorations. In bleaching silk or wool, deoxidizers or reducing agents, such as sulphurous acids or fumes of burning sulphur, are required.

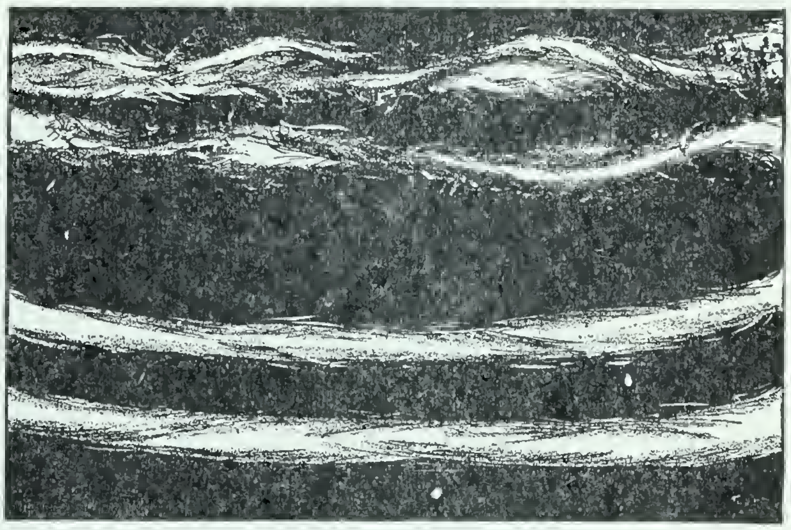


Skeins of yarn are being mercerized. Under tension, they are passed through a strong caustic solution.

*Bleaching Any Fabric.* Hydrogen peroxide, with or without a little ammonia or borax, can be used in bleaching any fabric. Ammonia or borax helps to clean and open the fiber to permit penetration of the peroxide. Ordinarily, a dilute solution of hydrogen peroxide is used to bleach wool materials.

**Mercerizing.** Mercerizing is an important preparatory process for cotton cloth. It is also used in the finishing of linen. Cloth is singed before mercerizing, but mercerizing may precede or follow bleaching.

Mercerizing changes the chemical composition of the fiber, strengthening its cellular lines by causing it to swell in diameter and to contract in length; the gain in strength may be as much as 20 per cent. Mercerizing is the simplest chemical method of producing luster in cotton and linen. In addition to increased strength and luster, this process gives fabrics greater absorbency for dyes. Mercerization can also be done in the yarn stage.


Before mercerization, cotton fibers show numerous short ends, as in the upper part of this drawing. After mercerization, the fibers are round, the yarn is smooth and lustrous, and twist is eliminated.

Highly mercerized fine cotton yarns can make cotton broadcloth shirting look like silk, and cause cotton damask to be mistaken for linen. When lisle yarn of high yarn count is mercerized, a silklike luster results that causes the material to be erroneously called "silk lisle."

Gray goods are mercerized by immersion in a specially prepared solution of caustic soda for about ten minutes under conditions of moderate uniform heat and tension. The caustic soda is washed out, and the yarn or cloth is put through a heated acid bath to neutralize the caustic soda. It is then rinsed in clear water and dried. The combined action of the caustic soda, heat, and tension changes and strengthens the fiber cells, thus improving and strengthening the cloth or yarn.

*Durene Finish.* The term Durene finish denotes a standardized process of mercerizing that utilizes a fine quality of cotton yarn. Manufacturers who maintain standards established by the Durene Association of America are allowed to label their product *Durene Yarns.* These yarns are made of fine long-staple combed cotton and are always of two-ply construction.

**Shrinking.** When fibers are spun into yarn, they are under constant tension during the weaving process. Their physical condition is changed, but it is not permanently fixed: the filaments will tend to revert to their natural state, causing shrinkage. The yarns are made to assume a final condition by shrinking the cloth in a preparatory finishing process; this minimizes subsequent shrinkage. There are several ways in which this is done.

Some methods comprise immersion in cold water, followed by hot water, steaming, or a chemical treatment. Any such method permits the manufacturer to label his product as preshrunk. But even when textile fabrics are preshrunk, they are liable to further shrinkage when they are washed. The most that can be expected from manufacturers is some specific information on the label stating the amount of additional shrinkage that may occur after washing.

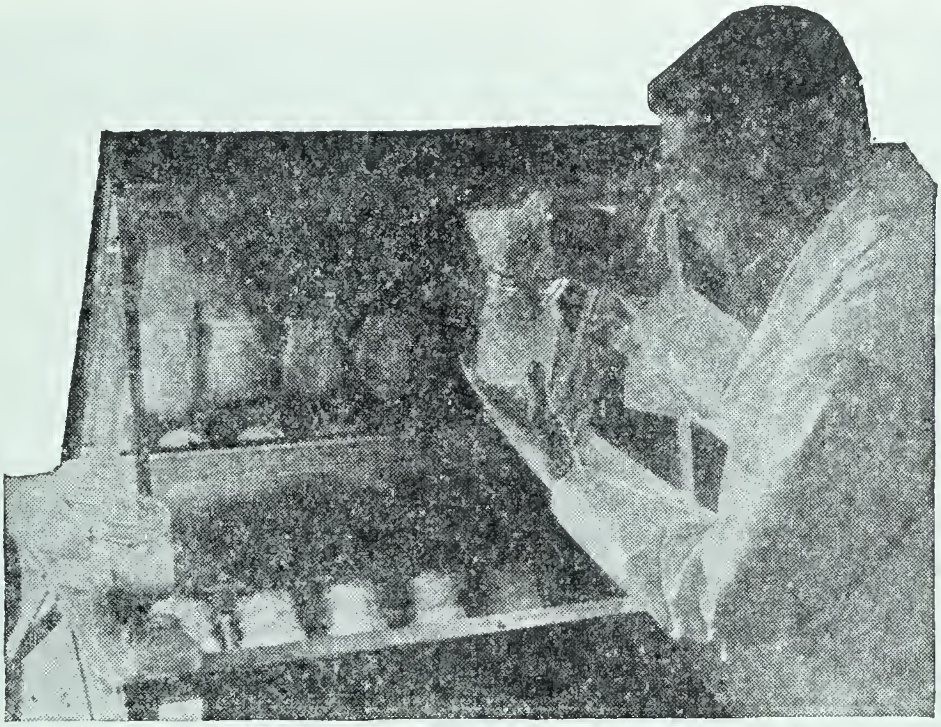
To realize maximum preshrinkage in finishing, the fabric must be given a preshrinking operation in which no tension is exerted while the fabric is damp. General adoption of such preshrinking methods for all fabrics is not feasible. Additional expense is incurred, and in some cases prized qualities inherent in certain fabrics are sacrificed.

In general, the factors that control shrinkage are the stability of the fiber and the construction of the fabric. Construction is based on the type of weave, the amount of twist in the yarn, the cloth count, and the yarn count. The kind of final finishing process also affects shrinkage; for example, a water-repellent quality in a fabric offers resistance to subsequent shrinkage.

The present rulings on shrinkage issued by the Federal Trade Commission apply only to cotton fabrics. If the label on cotton goods mentions shrinkage, the fabric must conform to these rulings. One important provision states that if a product is to be labeled preshrunk or shrunk, the label must specifically indicate how much additional shrinkage is to be expected. Formerly, a manufacturer's label reading "fully shrunk" or "will not shrink" or "shrinkproof" did not guarantee that substantially more shrinkage would not take place with continued laundering.

*Launderometer.* A machine known as a launderometer is used to make washing tests in testing laboratories. A similar, though larger, machine is used for determining shrinkage. Measured distances are marked in indelible ink or with fine threads on unwashed samples of the fabric. The samples are then placed in glass jars containing a washing solution. The jars are sealed and rotated in a tank filled with water that is maintained at a constant temperature. After an interval, the samples are removed, dried, and pressed. By observing any change in the measurements marked on the samples, the amount of shrinkage is determined.

*Compressive Shrinkage.* Compressive shrinkage is a patented, standardized method that has succeeded in reducing shrinkage in cotton and linens to a practical minimum. The cloth is deliberately shortened in both width and length, resulting in a tighter and closer weave and, consequently, in a higher cloth count. Fabrics shrunk by this method are frequently identified as "Sanforized." This term is a registered trade-mark and indicates that the fabric has a residual shrinkage of less than 1 per cent and that tests have been made to insure that it conforms to this standard.

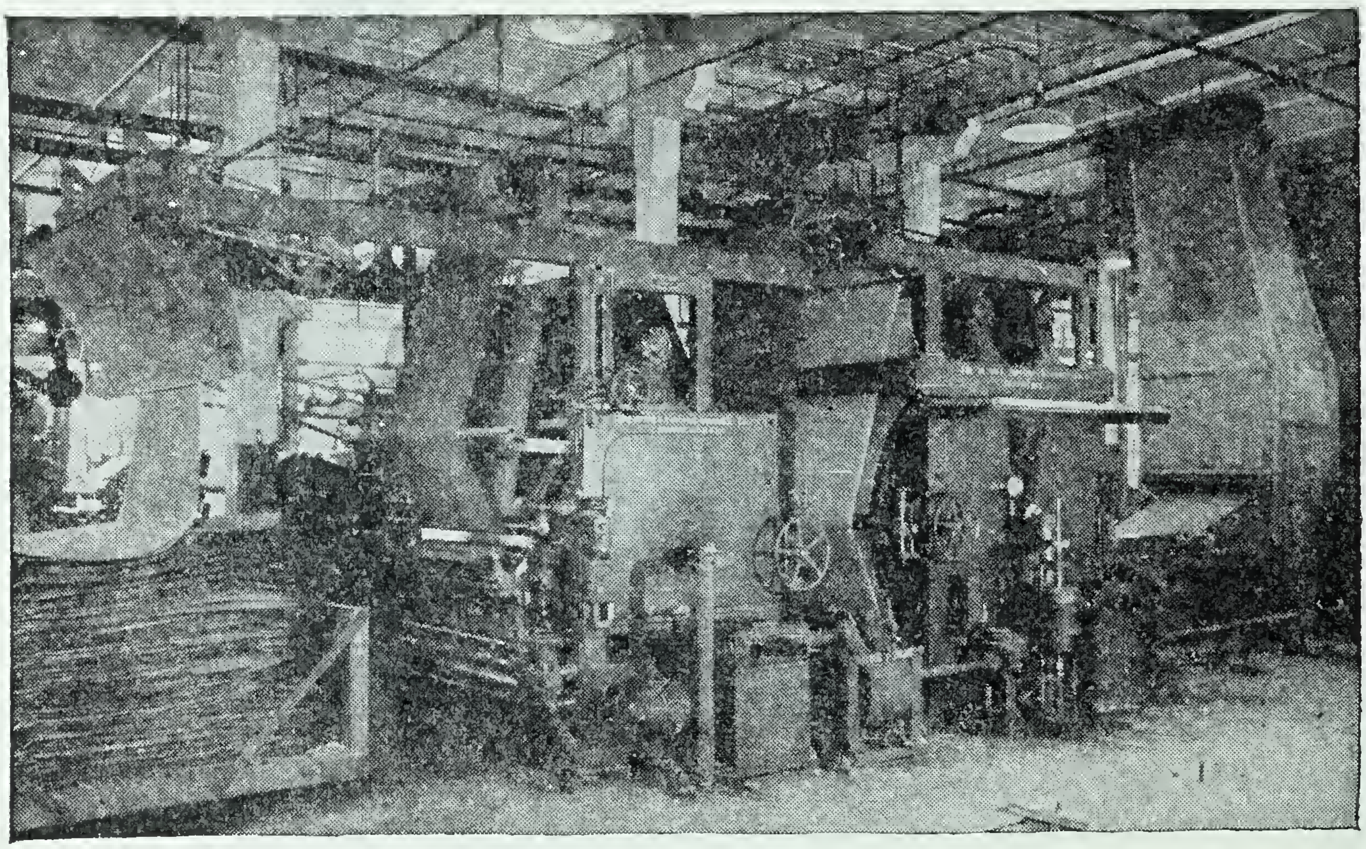


The launderometer is used to determine colorfastness in washing. A sample of the goods is placed in a soapy solution in a sealed jar.

The compressive-shrinkage process is carried out on a machine, which is about 65 feet long. The several steps in the process are:

1. Normal shrinkage is determined by subjecting a test sample of the fabric to ordinary washing conditions, using the United States Government wash test.
2. Careful measurements before and after the wash test indicate how much the fabric shrinks in length and width.

3. The compressive-shrinkage machine is set to shrink the fabric to the exact dimensions that the wash test indicated.
4. The fabric is dampened with pure water and live steam, which soften it in preparation for the adjustments to be made in length and width.
5. The width is adjusted by a stretching action, in which the fabric is gripped along its selvages.
6. The fabric is then held firmly against a heavy wool blanket which is under controlled tension.



Cotton and linen may be preshrunk at the mill in a compressive-shrinkage machine.

7. As the tension of the blanket is relaxed to the desired measurements, the fabric shrinks uniformly in length.
8. The fabric is then carried around a heated drum while drying, and the surface finish is restored.
9. A sample is tested again to make certain that additional shrinkage will not exceed 1 per cent.

*Rigmel Shrinking.* Rigmel shrinking is a patented method of mechanical shrinking, somewhat similar to compressive shrinkage, in which a cotton fabric is put through a standard wash test to determine the precise shrinkage in inches per yard, and is subsequently shrunk to planned dimensions that permit anticipation of residual shrinkage.

**Fulling.** The process of fulling, an important operation in the finishing of wool fabrics, actually operates as a preshrinking process for wool. The fibers are cleaned, scoured, and condensed by a combination of moisture, heat, soap, and pressure. Sometimes chemicals are added to increase the adhesion of the fibers. The condensing is a natural result of the felting property of wool fiber—shrinkage takes place because the fibers are drawn together. As a result, the fabric has a fuller, more compact body.

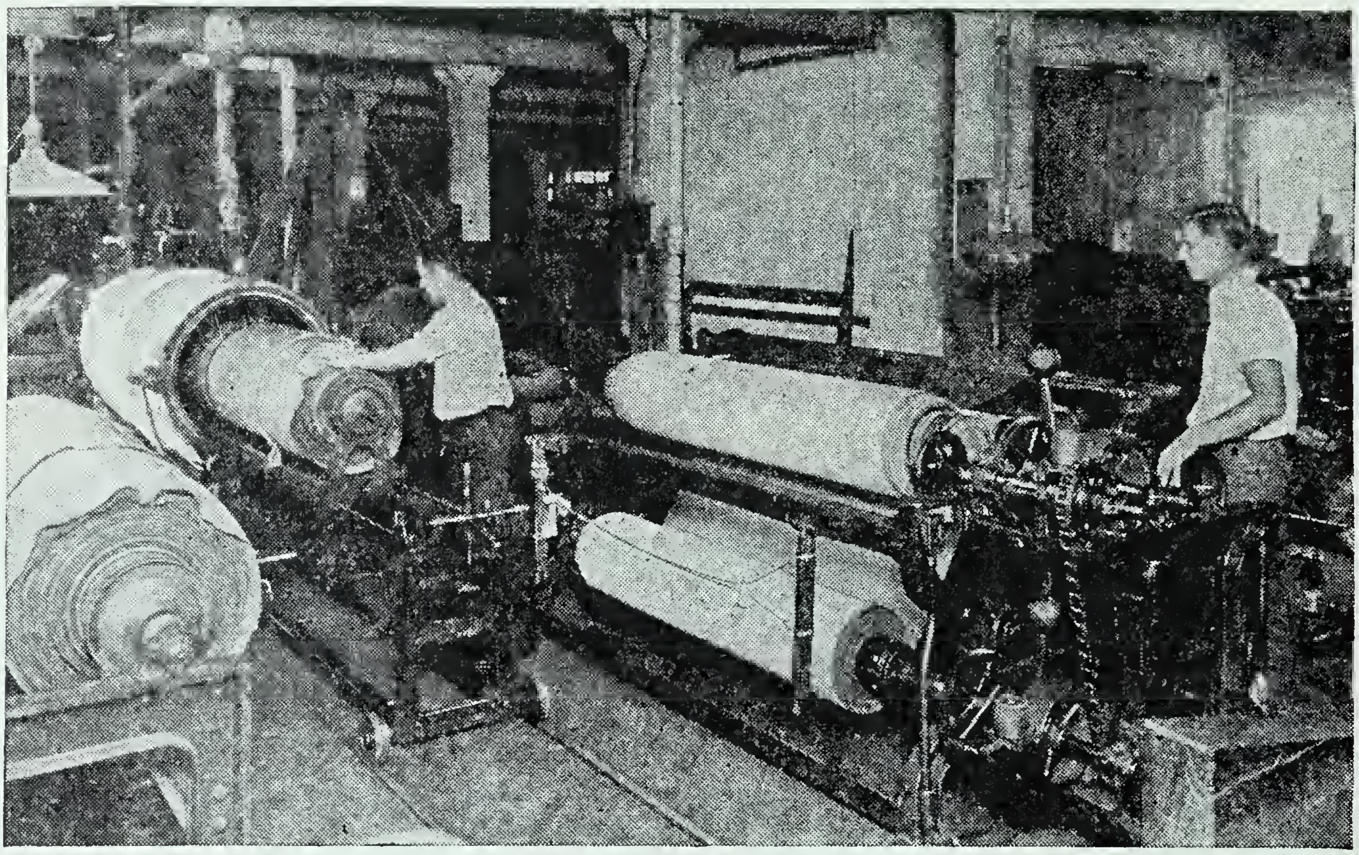
*Cylinder Method.* This method for shrinking wool uses two perforated cylinders, which steam the fabric as it is rolled off one cylinder and rewound on the other. The steamed fabric is then wound loosely around a wood roller, where it dries and cools slowly and naturally.

*Chlorination Process.* Another method for shrinking wool is the chlorination process, in which the wool fabric is treated with a dilute solution of calcium or sodium hypochlorite. Some of the scales of the fibers are removed, causing fusion of the outer and inner part of the fibers. As a result, shrinkage decreases. When this protective scaly covering is removed, however, the felting quality is lessened, and the durability of the fabric is affected; but luster and affinity for dyes are increased. Steaming or fulling does not have this result. Chlorinated wool is chiefly used in woolen underwear.

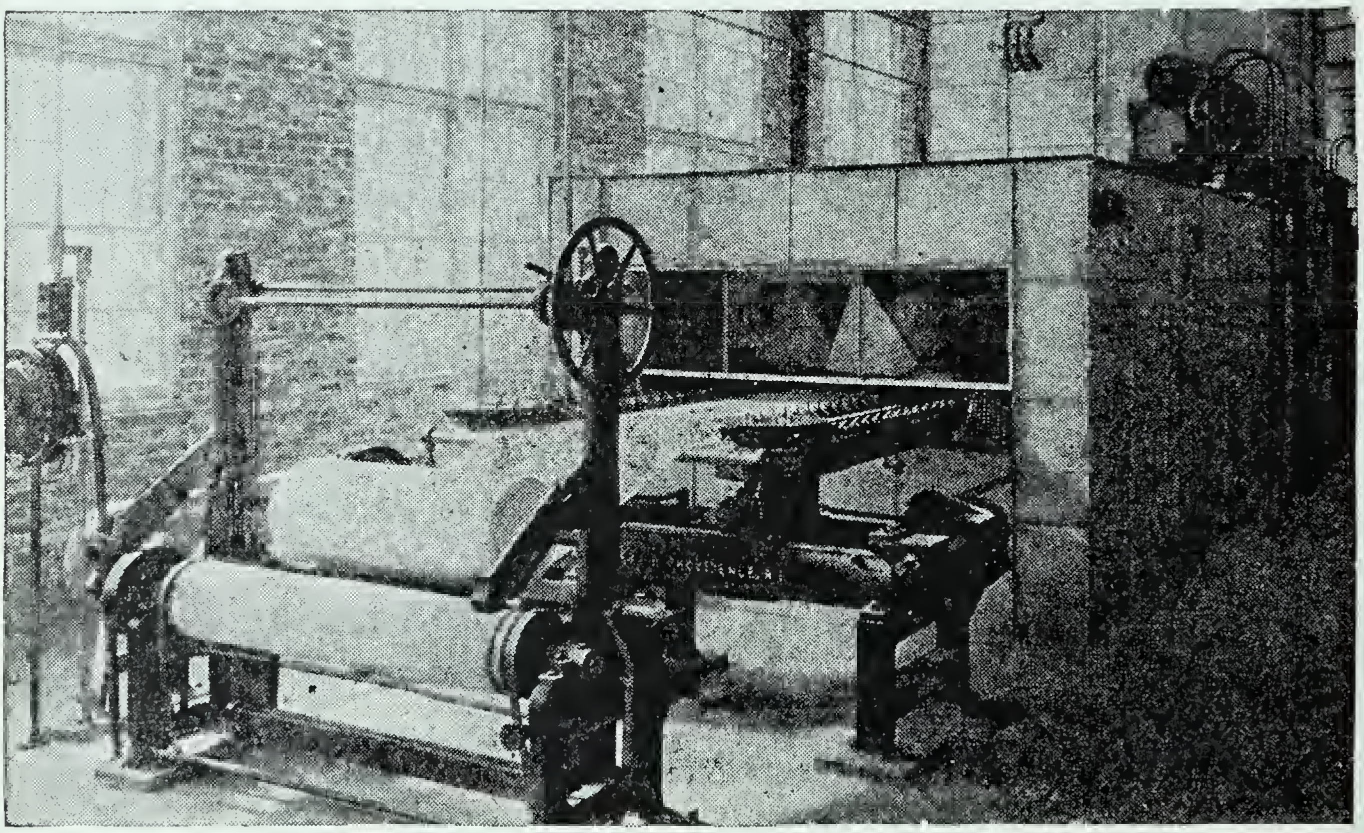
*London Shrinking.* London shrinking is a cold-water process of shrinking wool fabrics. Lengths of wool material are retained between wet blankets for about twenty hours. The moisture of the blankets penetrates into the fibers of the cloth. The cloth is then dried slowly and subsequently subjected to a hydraulic pressure of about 3,500 pounds. Cold-water shrinking originated in London. It is considered one of the best methods of preshrinking wool fabrics.

**Tentering.** As a fabric passes through various finishing processes, it becomes irregular in width. In order to restore it to its proper width, the cloth must be stretched in some parts and shrunk in others. This process is called *tentering.* It is done on a machine that grips the cloth along the selvages with movable clips in chain form, so that the cloth can be jerked along its length.

The cloth is fastened on the tentering machine while it is moist, and steam is sprayed from underneath to aid in the stretching and shrinking. Before the cloth leaves the machine, it is dried by heating



By the cylinder method, wool fabric is steamed through perforations as it is wound from one cylinder to another. The steamed fabric is then loosely wound on a wooden roller and is allowed to dry slowly and naturally.



In the tentering machine, the cloth is gripped by steel clamps in order to restore the fabric to its original width.

devices. Occasionally, the tiny holes or marks of the clips are noticeable in the selvages of yard goods.

In properly finished fabrics the filling threads are at right angles to the warp. If the angle varies, the fabric is described as "on the bias." Tentering helps to straighten the warp and filling threads and to smooth the fabric.

**Crabbing.** In finishing wool fabrics, a stretching process called *crabbing* passes the cloth over rollers into hot water or steam. The cloth is then put into cold water, after which it is pressed.

This process is similar to tentering, as the cloth is stretched or loosened where necessary and finally set at the width at which the warp and filling yarns are in proper relation to each other. Consequently, there is no hidden strain on any portion of the cloth. Crabbing also prevents the formation of creases or other forms of uneven shrinkage in subsequent finishing operations.

**Sizing or Dressing.** Cotton and linen can be given stiffness, smoothness, weight, and strength by immersion in a solution of starch. This process is commonly known as *sizing.* A small amount of starch in consumers' goods, especially in cotton fabrics, helps to retain freshness while the goods are on the dealers' shelves. Cotton fabrics that are usually sized are organdy, lawn, voile, and buckram.

Some sizing is acceptable, but the consumer should refrain from purchasing materials that have too much sizing because it may conceal inferior construction. Sizing fills in the openings in cloth, creating an appearance of greater compactness; thus, a low cloth count is not immediately discernible at the time of purchase. If a material loses body after one or more washings, it has been oversized.

Excessive sizing can be detected by rubbing the fabric between the hands. This causes the sizing to come off in the form of a fine powder. An absolute test can be made by touching the fabric with a drop of weak iodine; if starch is present, a blue color appears.

Other substances used for dressing materials are flour, dextrine, glue, shellac, fats, wax, and paraffin. The starches give weight; glue gives the starches tenacity; fats give softness; wax and paraffin produce luster. Starch, baked brown before using, is known as dextrine, or British gum; in this form it gives a soft dressing to a fabric.

Cotton fabric is sometimes sized with clay chalk, barium sulphate, calcium sulphate, or magnesium sulphate to make it especially heavy and close in texture. Some sizings make cotton fabrics susceptible to mildew, but this tendency can be offset by the addition of zinc chloride to the sizing bath.

*Glazing.* A stiff polished or glazed surface can be applied by the use of starch, glue, mucilage, or shellac. The process makes a fabric resistant to dust and spots, and minimizes shrinkage. This finish is found principally on chintz. Everglaze and Vita-glaze are typical trade-marked names for this process.

*Permanent Sizing.* Permanent sizing effects can now be achieved without the use of starch. A chemical process changes the cellular structure of the fiber. By this method, sheer and medium-weight cottons are given stiffness, which sometimes lasts throughout the life of the fabric. These processes are known by specific trade names. They vary in method, in the chemicals used, and in the degree of permanency of the final finish. Some of these finishes are known by the following names.

*Bellmanizing.* In the Bellmanizing process, permanent crispness can be given to sheer cottons by sealing the fibers chemically with resinous compounds. The fibers undergo basic structural changes—they become round, stiff, and firm. As a result, the fibers become resistant to untwisting, fraying, and creasing. The chemical compounds do not dissolve in laundering. No starch is used in the process, nor is starch required in subsequent washing. The Bellmanizing process is effective on sheer cottons, such as batistes, lawns, voiles, and organdies.

*Saylorizing.* Saylorizing is a starchless finish similar to the Bellmanizing process. It gives permanent crispness to medium-weight as well as to sheer cottons.

*Staze-Right.* The finish known as Staze-Right gives luster and crispness to organdies and marquisettes, and is resistant to washing and dry cleaning.

*Sheercroft.* Sheercroft is a starchless finish that imparts crispness and increases luster, giving cotton a linenlike appearance.

*Stabilized.* The Stabilized process gives a finish like sizing. It also adds body to spun rayon and to cotton, but the finish is not permanent.

*Ankord.* Ankord, a starchless finish given to cotton and rayon gray goods, increases tensile strength, improves luster, and reduces shrinkage.

Starch is not required when the fabrics are laundered. The finish is resistant to washing and to dry cleaning.

*Basco.* The starchless finish known as Basco increases strength and gives permanent luster and a linenlike appearance to fabrics.

*Trubenizing.* Trubenizing is a patented process that prevents wilting in collars and cuffs. Cloth made of acetate yarns is used to interline the collars and cuffs, which are then immersed in acetone and pressed with a hot iron; the result is a permanent stiffness that does not require starching.

**Weighting.** Cloth is sometimes weighted to give it additional body. When cotton cloth is weighted with any of the various sizing agents, it is heavier and appears to be closely constructed. Its poor construction becomes apparent after washing, however. The consumer should learn to judge such materials for their quality, not for their apparent weight.

Weighted silk fabrics have become acceptable in the textile industry; but if excessive metallic salts are used in the weighting, they eventually weaken the fabric. The Federal Trade Commission has therefore issued specific regulations with respect to kinds of weighting and their proper labeling.

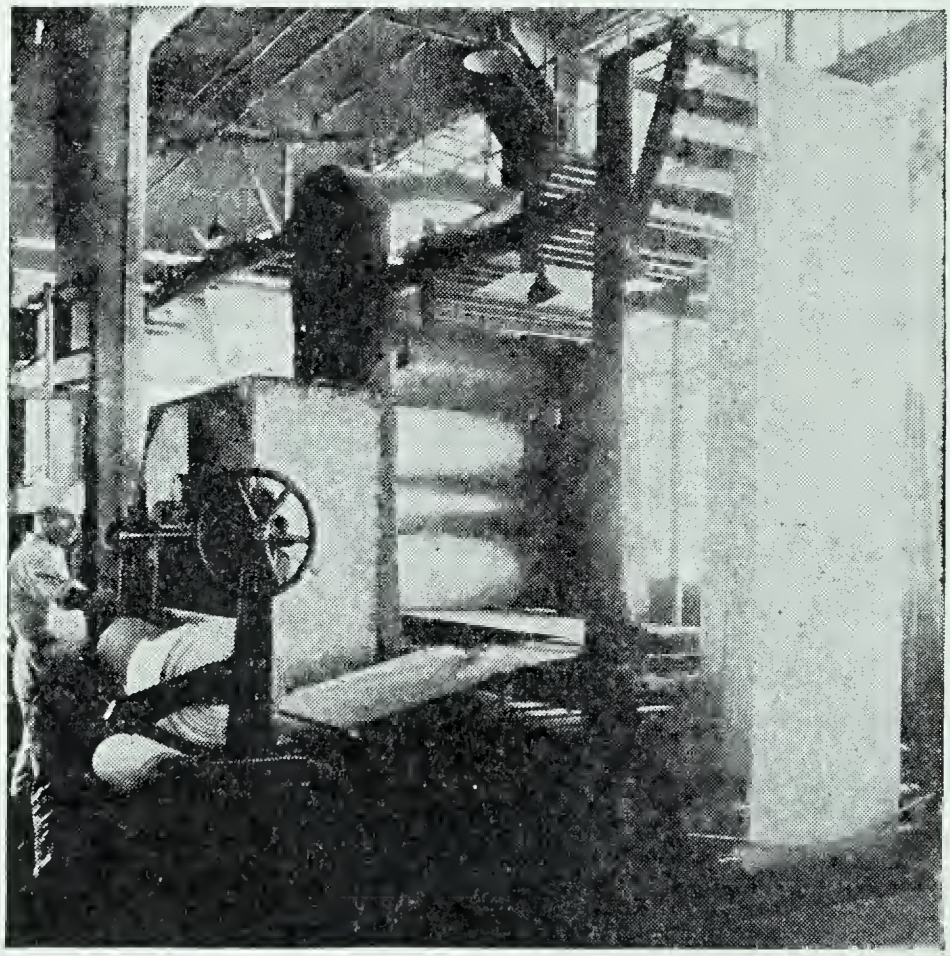
Only low-grade wool fabrics are weighted. As much as 40 per cent additional weight can be obtained by felting extremely short wool fibers into the cloth. These fibers, which are called *flocks,* are obtained when wool fibers are washed, brushed, and sheared. The use of an excessive amount of flocks can be detected by brushing and shaking the fabric vigorously. Careful examination of the selvage will also reveal flock particles.

Additional weighting has been gained by treating wool cloth with magnesium chloride, which causes an excessive water content. This spurious practice gave rise to the expression, "watered stock."

**Calendering.** Calendering is essentially an ironing process. It presses out folds or creases in the cloth by passing it around a series of heavy, highly polished steam-heated rollers that move at different rates of speed and have varying degrees of heat. Calendering flattens the fibers, removing inequality of surface; it imparts smoothness and luster, but not permanently.

For highly lustrous effects, the cloth is sized before it is run through the calendering machine. The smoothness and the luster are determined by the degree of heat and the amount of pressure, also by the amount of sizing, if any is used.

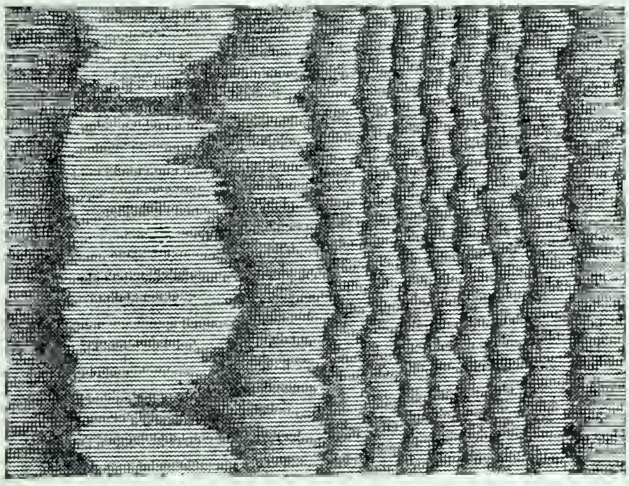
The calendering process varies according to the type of finish desired. Where a light calendering effect is intended, the cloth is passed between cylinders without heat. The pressure alone removes wrinkles and imparts smoothness.



Calendering eliminates wrinkles. The cloth is passed between heavy, highly polished steam rollers at different rates of speed and varying degrees of heat.

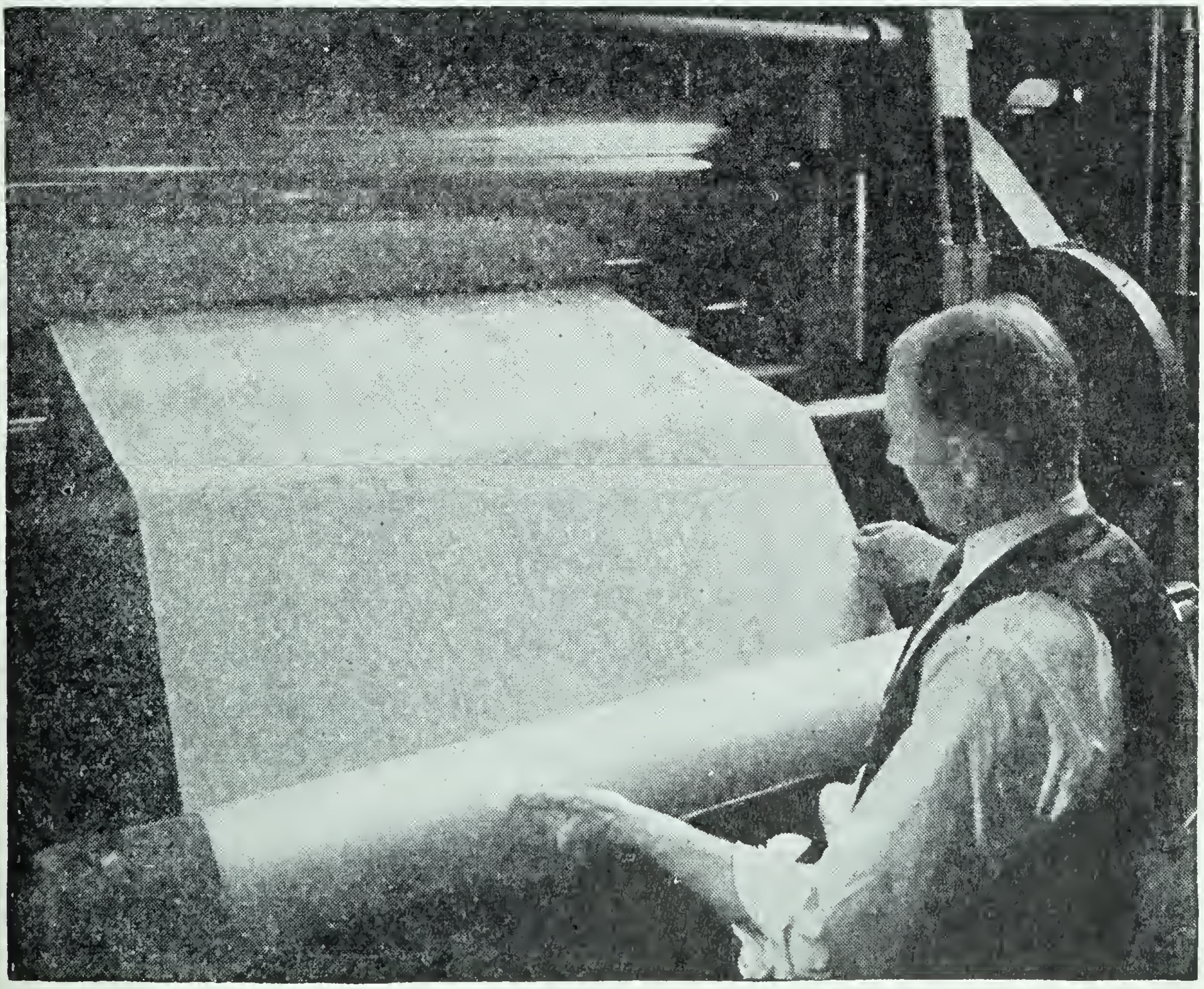
**Schreinerizing.** Schreinerizing is an inexpensive method for imparting luster to low-priced cottons. Steel rollers, finely engraved with lines and exerting a pressure of 4,500 pounds, impress on the cloth diagonal ridges ranging from 125 to 600 to the inch. Reflection of light from these ridges gives the cloth a lustrous effect somewhat similar to that produced by mercerization. But the luster produced by schreinerizing is not permanent because the imprinted ridges disappear with repeated launderings. However, this finish is suitable for lingerie fabrics and for linings and sateens, as the slightly rough surface produced by the diagonal ridges reduces the tendency of fabrics to cling. If the fabric has been mercerized, the additional schreinerizing produces a luster that simulates that of silk.

**Moiréeing.** By attaching engraved rollers to the calendering machine, the attractive, lustrous wavy design known as *moiré* can be produced. The best moiré results are obtained on fabrics having rib effects in the filling. Fine lines are imprinted on the raised filling yarns by hydraulic engraved rollers capable of exerting over 100,000



*Left:* The best moiré results are obtained by imprinting the pattern on ribbed fabrics. Luster is produced by divergent reflections of light on the lines of the design.

*Below:* Engraved rollers have produced this permanent moiré pattern on acetate rayon.



pounds pressure to the square inch. The luster is produced by the divergent reflection of light on the lines of the design.

A moiré pattern in a regenerated rayon weave is more lasting than the same pattern in silk, because the natural elasticity of silk does not permit the permanent retention of an embossed design. In acetate rayon, moiré is definitely permanent, because acetate fabrics have a melting reaction when subjected to the heat of the moiréeing process, thus absorbing and hardening the pattern as the cloth cools.

**Beetling.** Beetling is a common finishing process for linen. It gives the cloth a firm, flattened, lustrous appearance. All table linen is put through this process, but dress linens are never beetled.

In beetling, the cloth is hammered; the yarns are flattened by the impact of wooden mallets. This hammering actually closes the weave and creates a heavy and compact appearance. Luster is an accompanying result.

Beetling differs from calendering. The smoothness and gloss obtained by the calendering process are the result of horizontal pressing and are not permanent, whereas in beetling the action performed is a vertical impact that permanently flattens the yarns.

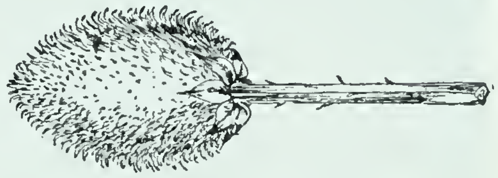
Cotton fabrics can be made to simulate linen by beetling, as the process gives cotton the firm feel and lustrous appearance of linen.

**Napping.** A napped fabric should not be confused with a pile-weave fabric. In the pile weave, the thickness of the cloth is a true third dimension produced by loops from an extra warp or filling yarn. In the napped fabrics, the thickness of the cloth is only a surface fuzziness that is the result of a brushing process. When a fabric is to be napped, the yarns intended for the construction of the cloth are given only a slack twist in the spinning process.

The fuzzy finish produced by napping makes a soft fabric, which provides warmth because of the insulative air cells in the nap. The thicker the nap, the more air cells, and the warmer the fabric. In men's suitings, where long wear is desired, a napped surface acts as a protection against objectionable luster. The fact that stains can be removed easily from a napped surface is an additional advantage. On the other hand, napping may also serve to cover up a sleazy construction as well as weaving imperfections. It is generally considered that excessive napping tends to weaken the fabric, especially where a heavy nap has been produced.

Single napping signifies that both sides of a cloth have been napped in one direction; double napping signifies that both surfaces have been napped in opposite directions, which produces greater surface density, increased firmness, and greater warmth. Flannelette, wool flannel, suede cloth, duvetyn, and all woolens exemplify napped fabrics. Cotton and spun-rayon fabrics are napped when a soft, fuzzy surface is desired.

Vegetable burs called *teasels* are used for napping finer grades of wool fabrics. Long cylindrical rollers containing closely set wires, which act like brushes, also perform the teaseling operation. As the brushes slide over the revolving fabric, they pull the top fibers and raise the protruding ends above the surface of the cloth in the form of a fleece-like nap. If a heavy nap is desired, teaseling is repeated several times.



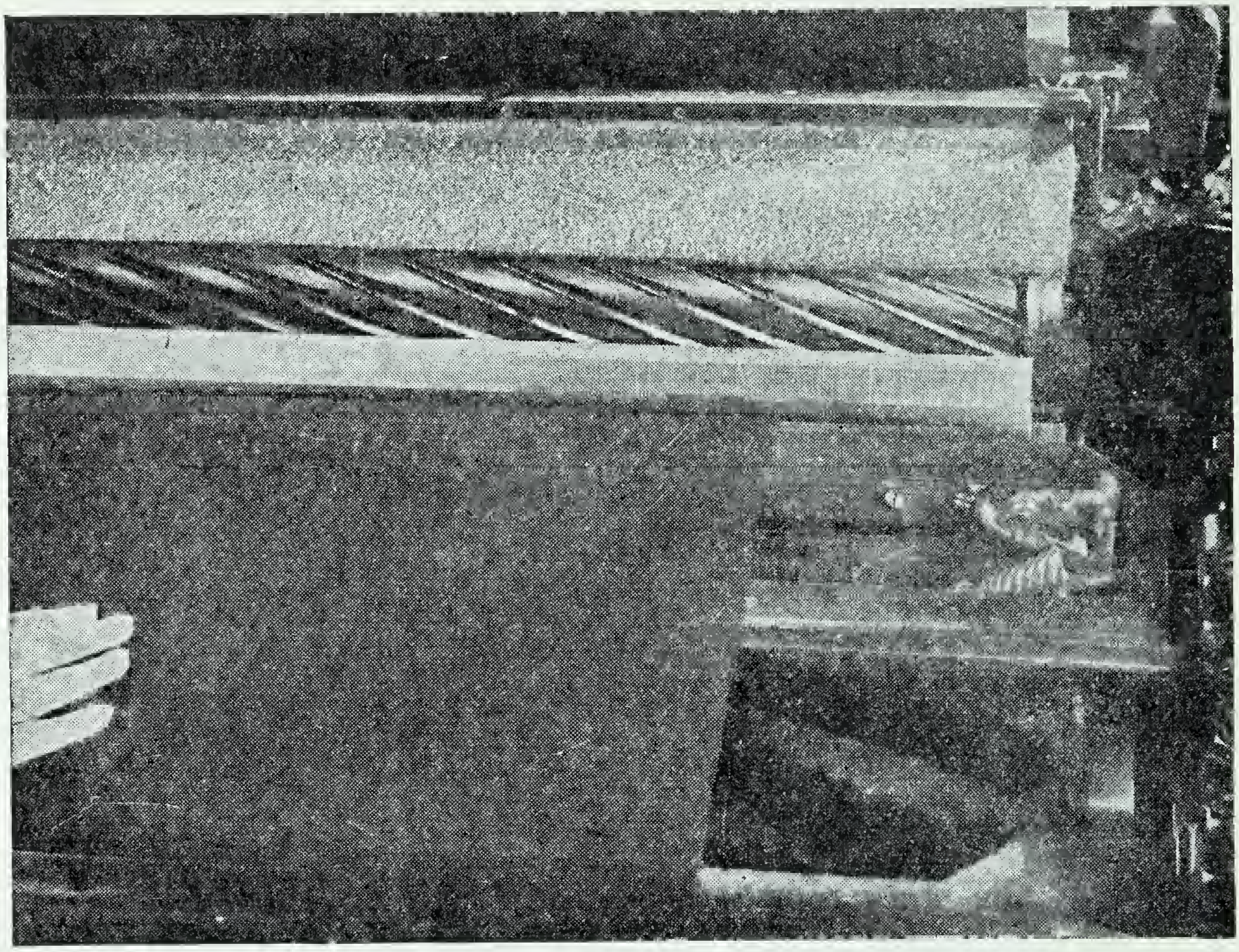
The teasel, a dried flower head with stiff, hooked bracts, is used to produce the fuzzy surface on napped fabrics.

*Gigging.* Wool fabrics may be napped, or they may be subjected to a raising process called *gigging.* The fabric is first saturated with water. When the fibers of a moist wool fabric are raised, they tend to curl and shrink. They are then brushed in one direction. A smooth and lustrous appearance results.

**Shearing.** Pile-weave fabrics and fabrics that have been napped are usually sheared in order to give an attractive smooth surface to the cloth. Shearing levels all surface irregularities caused by the plucking action of the teasels in the napping process. Shearing is done by a cylindrical machine having rotating spiral blades whose action resembles that of a lawn mower. After shearing, the fabric is automatically brushed in order to remove the sheared ends of the yarns.

**Crepe and Crinkled Effects.** The permanent types of crepe effects are obtained by the use of hard-twisted yarns in the weaving process, as described in Chapter III. Crepe surfaces can also be produced by certain finishing processes, but the results are not so satisfactory.

One of the finishing methods imprints a crinkled effect by means of engraved rollers. The effect is similar to that produced when the



A rotating spiral blade shears surface irregularities from napped and pile fabrics. A brush (shown in lower part) removes the sheared ends.

thumbnail is drawn across tissue paper. The finish disappears with repeated washings, however.

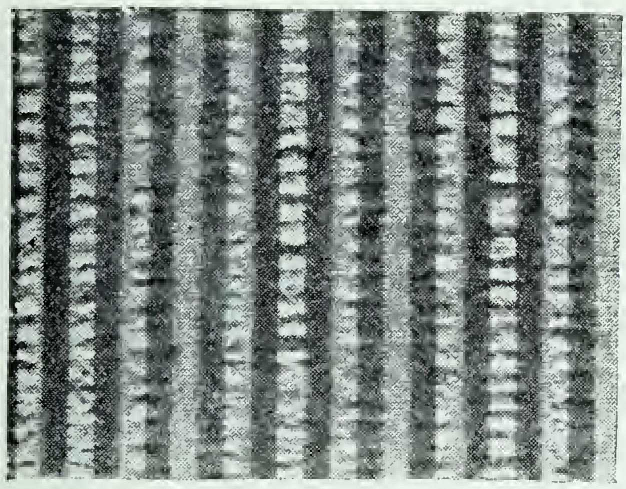
In another finishing method, caustic soda is impressed on the cloth in the form of figures or stripes. The cloth is then washed; the parts imprinted with the soda shrink, and the other portion of the cloth puckers. A similar effect is obtained by using strips of wax in place of the caustic soda. Plissé crepes are produced by these methods.

The nonpermanency of these crepe effects can be easily detected by pressing the thumb heavily on a portion of the cloth and stretching the cloth sidewise at the same time. The pressed portion will be smoothed; no ripple will be felt on its surface.

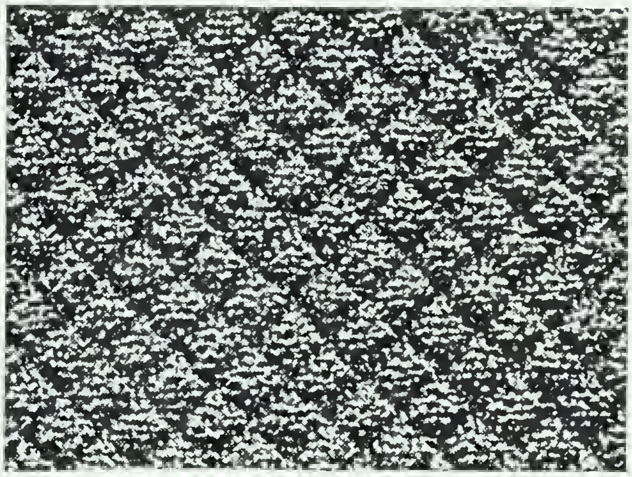
A chemical method gives a crepe effect to silk by treating the cloth with concentrated sulphuric acid for a few minutes, followed by rinsing and neutralization with a weak alkali. There is a decrease in luster and a slight loss in strength. This method calls for careful manipulation, as too long an exposure in the acid injures the silk.

All crepe fabrics tend to stretch and shrink when subjected to any wetting operation.

**Crease Resistance.** Both silk and wool enjoy a quality of elasticity that makes them resistant to wrinkling, creasing, or crushing. The vegetable fibers do not have such inherent elasticity. Slacks made of cotton, linen, or long-staple rayon, for example, are not so serviceable as wool slacks because the vegetable fibers crush easily. A crease-resistant finish for these fabrics is therefore very desirable. Such a finish may be obtained in several ways.



In seersucker, a crinkled effect is obtained by the use of slack warp yarns.



In matelassé, a crinkled effect is produced by the Jacquard.

The use of short-staple yarn, particularly in linen and rayon, produces a quality of softness in the fabric that makes the fabric crease-resistant to some degree, but durability is sacrificed.

The soft surface of a napped fabric also gives crease resistance. Fabrics with crepe surfaces possess a real crease-resistant quality, the degree being determined by the process used to produce the crepe surface.

Chemical methods are also used to give cotton and linen fabrics varying degrees of elasticity by impregnating the yarns with synthetic resins and gums. Phenol formaldehyde, urea formaldehyde, and acrylic resins are most commonly used. These produce an elasticity that does not disappear with dry cleaning and washing if the fabric is handled with care. There are several such patented processes on the market today.

*Anticrease Finish.* In the anticrease process, a solution of formaldehyde resins is baked into the cloth, penetrating the fibers and resulting in a softened flexible cloth. Fabrics so treated are not absolutely crease-resistant, but they resist crushing and recover easily. These fabrics also tend to shrink less in laundering. Because of the added weight of the resin, drapability is increased.

*Vitalized Finish.* The Vitalized finish, also known by its English trade name Tebilized, is a patented crease-resistance process similar to the Anti-crease finish. It gives additional "vitality," or elasticity, by the use of synthetic resins. It is applicable to both cotton and linen cloth. Fabrics so treated are heavier and shrink less. Washing or dry cleaning does not affect the vitalized quality.

**Waterproofing.** There is only one method of making a fabric permanently waterproof: by coating the surface of the cloth with rubber or with plasticized synthetic resins treated with solvents. The application of either of these solutions, repeated if desired with separate dryings, and subsequent vulcanizing or baking, closes the pores of the fabric, making it permanently impervious to water. But such waterproofing has the disadvantage of giving excess weight to the fabric and eliminating porosity, so important for health and comfort. When rubber solvent is used, cracks eventually appear in the surface coating.

Consumers have therefore indicated a preference for materials that have been subjected to processes that make them repellent to water rather than absolutely waterproof. Water-repellent fabrics are sprayed or brushed with resins, waxes, metallic soaps, or linseed oil. These substances impregnate the fibers of the cloth and fill in the spaces between the yarns, giving the cloth a water-repellent quality. Water-repellent fabrics must not be confused with waterproof fabrics. A water-repellent treatment does not affect the natural characteristics of a fabric, including its porosity.

The protective coatings used in some of these processes tend to disappear when exposed to friction and wear. However, a water-repellent quality can always be restored to a fabric.

Silk can be made water-repellent by treatment with oil, both sides of the cloth being coated with linseed oil varnish. This method changes the original appearance of the fabric: it produces a smooth, hard surface and a quality of translucency. Oiled silk is popular for shower curtains and light raincoats for women.

Wool fabric has a natural water repellency that makes this fiber suitable for raincoats that are used in a light rain. Napped surfaces and fabrics with high cloth count have natural water repellency. When fine, highly twisted yarns are constructed into fabrics having a high cloth count, the garment is sometimes windproof as well as water-repellent.

Many patented processes have water-repellent features; some of these are: Cravenetting, Zelan, Aradex, Impregnole, Neva-Wet, Aqua-sec, Bandri, Hydrovised, Rainfoe, Repel-o-tex, Sayles Storm King, Wat-A-Tite.

*Cravenetting.* In the patented process known as Cravenetting, the fabric to be made moisture-repellent is placed in a solution of aluminum stearate, pressed until dry, and then passed through a tallow soap solution. The aluminum stearate is precipitated on the fabric. With continued wear, materials so treated may lose some of their rainproof quality, as dry cleaning and high temperature tend to decompose the aluminum stearate coating.

Any fabric can be made water-repellent by spraying it with a solution of paraffin in benzine; a fine coating of paraffin is produced on the material. This finish is not permanent.

*Zelan.* The Du Pont Company has patented a process, under the name of Zelan, that gives a water-repellent finish to cotton, linen, and viscose rayon. This finish can be applied to fabrics only under carefully controlled conditions, and must therefore be given to the unfinished cloth at a finishing plant.

To be effective, the Zelan finish must be applied after mercerization, especially before any other finishing agent, such as soap, salt, oil, gum, or starch, is used. The treatment contains no rubber, wax, nor insoluble soap. It does not coat the fabric but permeates and becomes a part of the fiber without impairing the natural porosity of the fabric.

Zelan is regarded as a permanent finish as its water-repellent quality endures repeated washings as well as dry cleanings. Other advantages that may be claimed for fabrics treated with Zelan are that stains and spots can be sponged off with a damp cloth, and that the fabrics resist perspiration and wrinkling, manifesting a softness of texture that improves appearance.

*Aradex.* The Aradex treatment, which is somewhat similar to the Zelan finish, uses a chemical emulsion that imparts qualities of water repellency, spot and stain resistance, and improved crease resistance. In contrast, the Aradex finish is not permanent, as it is affected by laundering and dry cleaning; but the finish can be restored after cleaning. Aradex does not coat the cloth, and thus permits the normal circulation of air. The appearance and feel of the fabric are not impaired.

*Impregnole.* In the Impregnole process a fatty emulsion is used that contains paraffin hydrocarbons and aluminum salts. This process makes cotton and wool fabrics water-repellent as well as resistant to spots, stains, perspiration, and wrinkles. One immersion is sufficient, and the emulsion is easily applied. Washing and dry cleaning remove this water-repellent quality, but the finish can be restored.

*Koroseal.* The Koroseal process can be applied to any finished fabric except acetate rayon. It makes fabrics impervious to water, wind, moths, and mildew and resistant to acid, grease, sunlight, perspiration, and stains. Koroseal fabrics do not contain any rubber or oil; consequently, they will not deteriorate by cracking, sticking, or peeling. Koroseal therefore serves a multitude of uses. The coating applied to the surface of the fabric is plasticized white powder, polyvinol chloride, which is obtained by compressing two gases—acetylene from coal and limestone, and hydrogen chloride from salt. The result is a tough, stretchable plastic coating having unusual properties.

**Fireproofing.** Only mineral, asbestos, glass, or metal substances are really fireproof. Textile materials cannot be made absolutely fireproof, but they can be chemically treated in order to retard inflammability. Fabrics so treated may be regarded as flameproof, which means that they will not flame or burn actively. Flameproofing is a practical form of fire protection where a fire-resistant quality is desirable, as in fabrics used for awnings, mattresses, work clothes, or draperies.

Some of the trade-marked names that indicate a fire-retardant quality are Du Pont, Fire-Retardant, Saniflame, and Neva-Flame. These processes are applicable to all fabrics except acetate rayons.

The objection to most fire-retardant compounds is that the fabric so treated loses this quality in washing or in dry cleaning. Also, such compounds sometimes affect the feel of a fabric, causing it to lose softness and flexibility. Where the fire-retardant quality is lost in washing or in dry cleaning, it can be easily restored by reprocessing with any of the commercial fire-retardant compounds.

Among the most effective flameproofing compounds is one that uses ammonium sulphamate; it makes a fabric fire-resistant without imparting a harsh quality. The fabric must be reprocessed after washing, but this is not necessary after dry cleaning, as the ammonium sulphamate finish is fast to dry-cleaning solvents.

Textile materials may be given a fire-resistant quality by a simple home method of immersing them in a solution of 70 per cent borax and 30 per cent boric acid. If the cloth to be treated is already water-repellent, soap should be added to the solution so that an even wetness and absorbency will be obtained. This method does not alter the appearance of the fabric, but the treatment must be repeated after every washing.

**Mothproofing.** Various commercial mothproofing compounds are available for use in the home. These patented compounds use one or more of the following chemicals: naphthalene (moth balls or flakes), paradichloro-benzine, ethylene oxide, and carbon tetrachloride. Some of these preventives are known to the consumer by such trade names as Larvex, Neva-moth, Demotex, and Amuno.

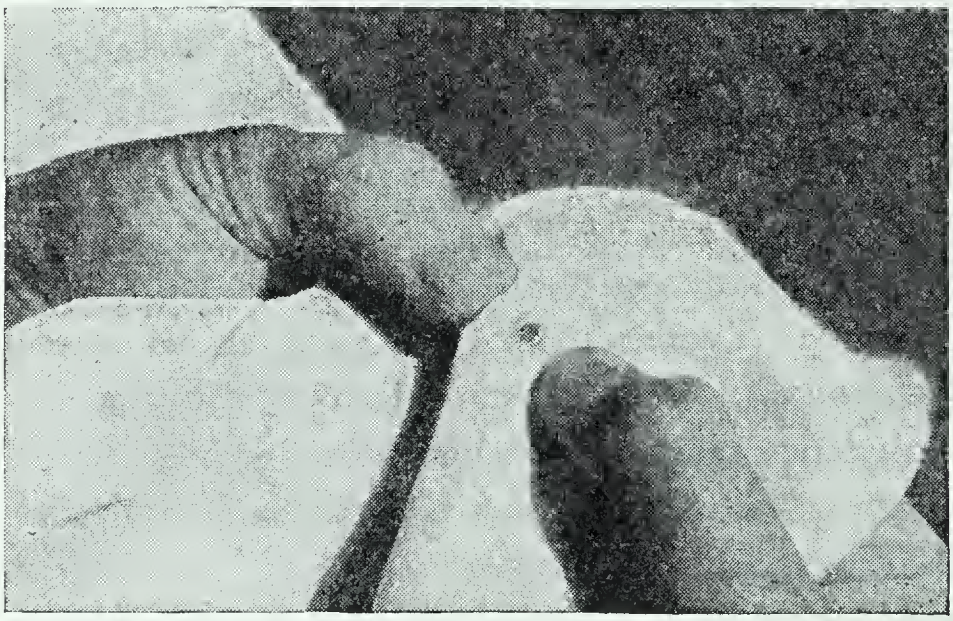
Solutions of inorganic compounds, such as sodium fluoride, sodium silicofluoride, and chromium fluoride, were used originally to make wool fabrics unpalatable to moth larvae. Fabrics so treated were unaffected by dry cleaning, but the mothproofing effect disappeared in laundering; thus a new treatment was required after each washing. However, the compounds are inexpensive and easily applied. A more enduring mothproofing process not affected by dry cleaning or washing is Eulan N, an organic compound that is applied in the dye bath and that impregnates the fibers. The texture and the color of the fabric so treated are not affected. A similar compound, Eulan N.K., can be used in the home as a spray.

Simple home methods of moth prevention comprise daily brushing of apparel after wearing, frequent exposure to sunlight, the use of air-tight wrappings (with or without naphthalene), and cold storage at a maximum temperature of 40 degrees Fahrenheit.

**Mildewproofing.** The use of sizing in finishing makes a cloth susceptible to mildew if the cloth is later exposed to moisture and warmth.

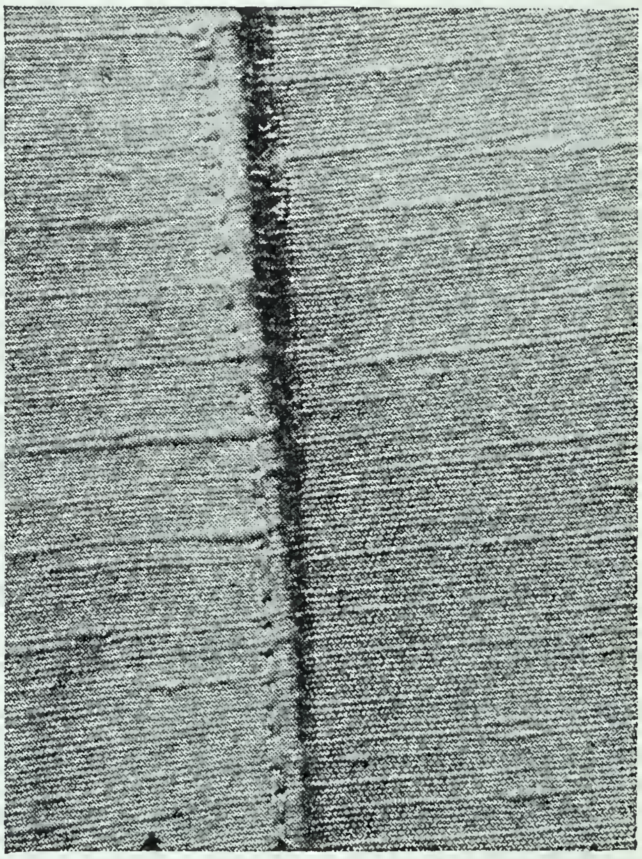
To prevent mildew, inorganic salts, such as magnesium chloride, calcium chloride, and zinc chloride, are used as warp sizing. Washing, however, tends to remove the mildewproof quality. Among recent developments has been the use of turpentine and formaldehyde as preventives. One compound that is not easily washed out is a 1–2000 solution of phenyl mercuric acetate in water. This is one of the most effective mildewproofing agents.

Shower curtains or other cotton fabrics may be mildewproofed in the home by soaking the material in very soapy water; then, without rinsing, dipping it into a solution of copper sulphate.



*Left:* When yarns shift easily, a fabric does not give good wear. Fabrics may be made slip-resistant by applying a resinous coating.

*Below:* Slippage at the seams may be the result of low cloth count as well as poor construction of the fabric.



Various antiseptics, such as boric acid and carbolic acid, also prevent rapid growth of the mildew fungus.

**Slip Resistance.** In fabrics that have a low cloth count, the warp yarns sometimes slip along the filling yarns. This action is known as *slipping.* Unusual wear or strain on some particular part of a fabric may also cause the same action. It is infrequent with rough-surfaced fabrics made of hard-twisted yarns.

Permanent firmness can be given fabrics by immersing them in synthetic resins, then stretching and drying the fabrics under tension. The deposit of resin at the points of interlacing in the weave prevents the yarns from slipping. This treatment is particularly advantageous for smooth-surfaced rayons, as the smoothness of the synthetic yarn causes it to slip and fray.

Fabrics labeled "slip-resistant" should be examined closely for cloth count, as the resinous coating may be used to create an effect of compactness in construction.

**Antiseptic Finishes.** Chemical antiseptic finishes impart a self-sterilizing quality to a fabric. The appearance and the feel of the material are unchanged, and no chemical odor remains. Dry cleaning does not impair the finish. Sanitized, Hygienized, Sani-Age, and Vita-Fresh are trade-marked names exemplifying these finishes.

*Test yourself on this chapter by answering these questions:*

1. Describe one important preparatory finishing process for smooth-surfaced fabrics.
2. Name six finishing processes for producing luster.
3. In each pair of the following finishes, which type is preferable and why? (*a*) Waterproof or water-repellent; (*b*) fireproof or flame-resistant?
4. What is the purpose of weighting? Why would it be unwise to buy a heavily weighted silk garment?
5. Explain two finishing methods by which a crinkled effect is achieved.
6. What is the result of the beetling process? How does it compare with schreinerizing?
7. How is starch used in finishing fabrics?
8. Explain the following processes: singeing, mercerizing, calendering.
9. How may a finishing process deceive the consumer?
10. Discuss shrinkage, telling (*a*) why it occurs, (*b*) whether it can be prevented entirely, (*c*) what methods are preferable for cotton, (*d*) what methods are preferable for wool.
11. Discuss the advantages of napping. Name the disadvantages, if any.
12. What fabrics are naturally crease-resistant? How can this quality be produced in other fabrics?
13. What method of bleaching is preferable? Is there any advantage in buying unbleached fabrics?
14. Why are finishing processes necessary?
15. Explain tentering and crabbing.

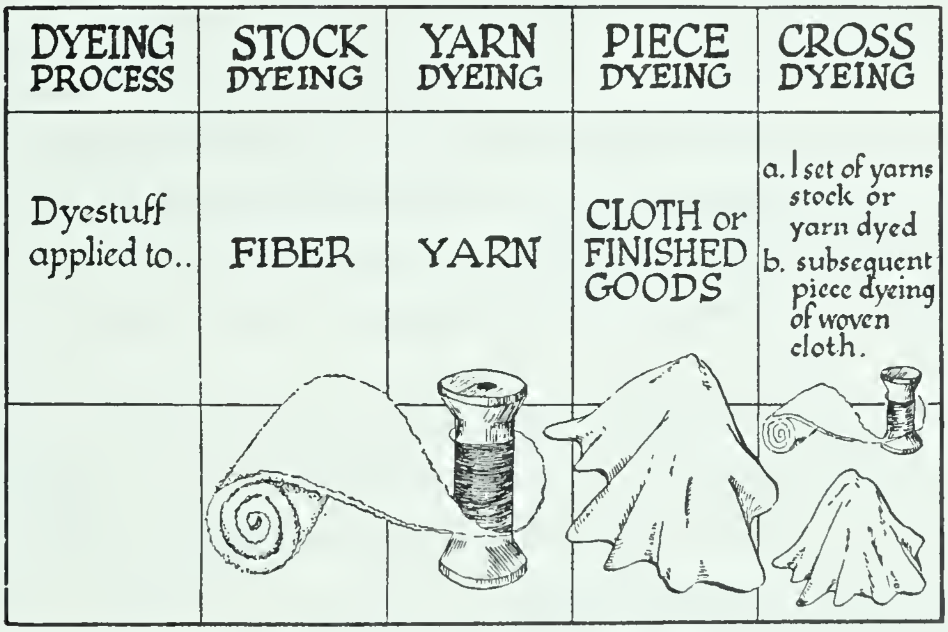
## Suggested Readings

Dooley, W. H., *Textiles,* Chapter 9.
Dyer, E., *Textile Fabrics,* Chapter 6.
Evans, M., and McGowan, E. B., *A Guide to Textiles,* Pages 53–66.
Hess, K. P., *Textile Fibers and Their Use,* Chapter 3, Section 1.
Matthews, J. M., *The Textile Fibers,* Chapter 18.
Nystrom, P. H., *Textiles,* Chapter 20.
Small, C. P., *How to Know Textiles,* Chapters 8, 10.
Wingate, I. B., *Textile Fabrics,* Chapter 12.

## CHAPTER VI

# DYEING: FINISHING WITH COLOR

As the major fibers have been examined and tested for their differential qualities, as their spinning and weaving processes have been explained, the qualities of durability and serviceability have been constantly stressed. When the yarn is woven into cloth, the interesting and intricate designs of weaves begin to add beauty of appearance as well as serviceability. The various finishing processes suggest additional means of enhancing the appearance of the newly formed cloth.



| DYEING PROCESS | STOCK DYEING | YARN DYEING | PIECE DYEING | CROSS DYEING |
|---|---|---|---|---|
| Dyestuff applied to.. | FIBER | YARN | CLOTH or FINISHED GOODS | a. 1 set of yarns stock or yarn dyed<br>b. subsequent piece dyeing of woven cloth. |

Methods and stages of dyeing.

It remains for the dyeing and printing processes to provide lasting beauty and delight to the eye; for both these processes add color to fabrics, and color delights by stimulating or soothing. Dyeing and printing differ in the method by which color is applied to cloth. In the dyeing process, fiber, yarn, or cloth is immersed in a solution of dyestuff, and is thus saturated with the dye. In printing (to be described in the following chapter), a pattern or a design is imprinted on the fabric in one or more colors by using dyes in paste form.

**Natural Dyes.** Primitive man obtained dyes from flowers, nuts, berries, and other forms of vegetable and plant life, as well as from mineral and animal sources. These same sources have provided what are termed "natural dyes" throughout the succeeding years of civilization.

The principal vegetable dyes are: fustic, sumac, catechu or cutch, madder, henna, saffron, logwood, indigo, and alizarin. Animal dyes, such as cochineal, squid sepia, lac, and Tyrian purple, are obtained from species of fish and small insects; minerals provide such dyes as Prussian blue, chrome yellow, and iron buff.

Natural dyes are no longer used in quantity by the dyeing industry, but they are still used in oriental countries to a certain extent for rug dyeing and in many parts of the world for native handicraft.

**Artificial Dyes.** Although artificial dyes were first derived from coal tar in 1856, they were not developed in the United States to any great extent until World War I, when the supply of imported synthetic dyes was cut off. Since then, the United States has built up a dye industry that is unsurpassed. Innumerable dye compounds made from coal tar have now supplanted natural dyes. These artificial or synthetic dyes are constantly being improved as to beauty of color and colorfastness.

Lasting beauty of color is an important factor in consumers' finished goods. Durability of color depends on: (1) selection of the proper dye for the fiber to be dyed; (2) selection of the method of dyeing the fiber, yarn, or fabric.

**Selection of Dye.** In order to select the proper dye for a fiber, it is necessary to know which dyes have an affinity for the vegetable, animal, or man-made fibers. In general, the dyes used for cotton and linen may be used for viscose and cuprammonium rayons; but it was necessary to produce a special class of dyes for acetate rayon.

When a dye colors cloth directly with one simple operation of immersion, without the aid of an affixing agent, the dye is said to be a direct dye for that fiber. Direct dyes are the easiest to produce, the simplest to apply, and the cheapest in their initial cost as well as in application. They are the most fugitive, however; that is, they are not fast to washing or to light. The term *bleeding* describes dyes that run in washing. If dye rubs off a fabric when the fabric is exposed to the friction of wear, the action is termed *crocking*.

Requirements for colorfastness differ. Fastness to *light* is important in draperies, for example, as they must stand strong light daily but do not need to be washed frequently. Fastness to *washing* is important in dress fabrics and household linens because they must undergo frequent washings.

Therefore, both the kind of fiber to be dyed and the intended use for the fabric enter into the selection of the dye.

**Mordants.** A dye that has an affinity for one type of fiber may not adhere to other types of fibers; but it is possible to dye finished cloth containing a mixture of fibers by using a mordant in the dye bath. Salts of metals and tannic acid are typical examples of such chemical agents. The mordant adheres to the fiber for which the dye has no affinity, and the dye adheres to the mordant. Dyes that are used with a mordant are called *mordant* or *adjective* dyes.

**Classification of Synthetic Dyes.** The synthetic dyes are classified as (1) acid, (2) basic or alkali, (3) neutral or substantive. The acid dyes are used chiefly for wool and the basic dyes chiefly for silk. The substantive dyes are a new class especially adapted for cotton, linen, and regenerated rayons. For this reason they are called direct cotton dyes. They are also known by the specific names that describe their method of application: direct or salt dyes, developed dyes, sulphur dyes, vat dyes, and naphthol or azoic dyes.

**Acid Dyes.** Acid dyes are direct dyes for wool; they are also used when delicate tints are required for silk. They are known in the textile industry as *commercial colors*.

Acid dyes are inexpensive and fairly fast to light, but they are not fast to washing. Acetic acid or sulphuric acid, and sometimes Glauber's salt (sodium sulphate), is used in the dye bath.

Wool may be given increased fastness to both light and washing by boiling the fabric in a chromate solution after the first dye bath. This is called *afterchroming*. A special group of acid dyes known as *chrome dyes* is used for this purpose.

**Basic Dyes.** Basic dyes are direct dyes and are used chiefly for silk because they give brilliant, full colors. Basic dyes are not fast to light, washing, perspiration, or atmospheric influences; they tend to bleed or crock. These dyes are frequently used as an aftertreatment for fabrics that have been previously dyed with acid colors.

Basic dyes may be used for cotton or linen. When so used, a mordant, such as dilute tannic acid, is used with tartar emetic.

**Direct or Salt Dyes.** Direct dyes for cotton and linen, and viscose and cuprammonium rayons are known as *direct cotton dyes* because they achieve very bright, full colors for that fabric. They are sometimes used for reclaimed wool and for inferior grades of wool. When so used, a small amount of acid must be used.

Because sodium chloride (household salt) is included in the dye solution, direct cotton dyes are also known as *salt dyes*; the salt helps to drive the color into the fabric by lessening the solubility of the dye in water. The process is one of simple immersion and absorption rather than one requiring affixing chemical agents or compounds. When direct dyes are used for cotton fabrics, they do not need to be bleached, except when a half bleach is necessary in order to prepare the cloth for light shades.

Direct dyes are not fast to washing. An aftertreatment with potassium bichromate or formaldehyde gives an additional degree of fastness in washing; a similar treatment with copper sulphate increases fastness to light. More expensive operations, such as are used in developed, sulphur, vat, and naphthol or azoic dyes, are designed to produce additional degrees of colorfastness.

**Developed Dyes.** Developed dyes are used for cotton, linen, and viscose rayon. The color is developed by additional treatments, which also make the dye fast to washing. But developed dyes are not fast to light. As these dyes do not bleed, they are called *tub-fast colors,* and are used for women's apparel that must withstand frequent washings.

Developed dyes cost more because of extra operations. After the fabric has been immersed in a suitable dye bath and rinsed, it is dipped in a cold acid solution of sodium nitrite; this process is known as *diazotizing.* The original dye is transformed into an active chemical, which is combined with a developer (beta naphthol) in another cold bath. This third treatment develops a new color that is insoluble in water and therefore fast to washing. Developed dyes are also fast to acids and alkalies.

**Sulphur Dyes.** Sulphur dyes are used for cotton, linen, and viscose rayon. These dyes are fast to washing, light, and perspiration. They have one weakness: excessive chlorine bleaching will strip the color. Sulphur dyes are more expensive than direct dyes because of the unusual care required in the extra operations.

Sulphur is insoluble in water, but it is made soluble with the aid of sodium sulphide and soda ash. The dyeing is done at high temperature and with large quantities of salt, which help to drive the color into the cloth. After immersion in the dye bath, followed by rinsing, the cloth is oxidized to the desired shade by exposure to the air or, chemically, by the use of potassium bichromate and acetic acid. The oxidizing process must be carefully controlled because penetration of the dye is retarded by premature oxidation. Also, oxidation changes sulphur to sulphuric acid, which may be harmful to the fabric. Excess chemicals and excess dye must be completely removed by thorough washing.

Sulphur dyes penetrate more thoroughly than any other dye because of the high temperature and the alkalinity of the dye bath. They are excellent for khaki and for the heavy piece goods used in work clothes. Sulphur dyes produce dull colors, such as navy, brown, and black. They are used for blacks more than any other dye. If stored for a great length of time, sulphur-dyed fabrics become tender.

**Vat Dyes.** Vat dyes are the fastest dyes for cotton, linen, and viscose and cuprammonium rayons. They are not only resistant to light and to acids and alkalies, but they are equally resistant to the strong oxidizing bleaches used in commercial laundries. In this respect, vat dyes excel sulphur dyes, which are not fast to chlorine washing. In reds and pinks, however, absolute colorfastness is sacrificed for brilliancy of dye. Consequently, a label stating that a garment is vat-dyed is not a guarantee that the fabric is absolutely fast to washing if the fabric is of brilliant color.

The name "Indanthrene" on labels indicates that a special type of dye has been used that is particularly fast to light and to washing. This type was among the first of the synthetic vat dyes.

The old-fashioned method of fermenting and steeping indigo in a vat gave vat dyes their name. They are prepared today on the same principle, but they are chemically purer and the process is shorter. Vat dyes are expensive because of the initial cost as well as the method of application. They are insoluble pigments; but they are made soluble in water by the use of a strong reducing agent, such as hydrosulphite dissolved in the alkali, sodium hydroxide. The fabric is immersed in this solution. Subsequent exposure to air or immersion in an oxidizing bath (bichromate) restores the dye to its insoluble form as a part of the fiber.

**Naphthol or Azoic Dyes.** Naphthol or azoic dyes are as satisfactory as vat dyes in their fastness to washing and to strong bleaching agents, but not in fastness to light. When a bright red that will be fast to washing and to light is desired for cotton or regenerated rayons, a naphthol red dye is used.

The method of applying these dyes is somewhat similar to that of developed dyes, as it involves diazotizing. The cloth is first immersed in naphthol, which impregnates the fibers; it is then dipped into the diazotized color bath. The dyeing is followed by thorough soaping and rinsing. Naphthol or azoic dyes are sometimes referred to as *ice dyes* because ice is frequently used to bring the dyes to a low temperature.

**Acetate Dyes.** When acetate rayon was first made, it could not be colored with dyes that were available at that time; but special acetate dyes were produced after experimentation. These dyes do not have affinity for any of the natural fibers or for the regenerated rayons (viscose and cuprammonium). They will dye nylon, but the final shade of the color will not be the same as the acetate shade.

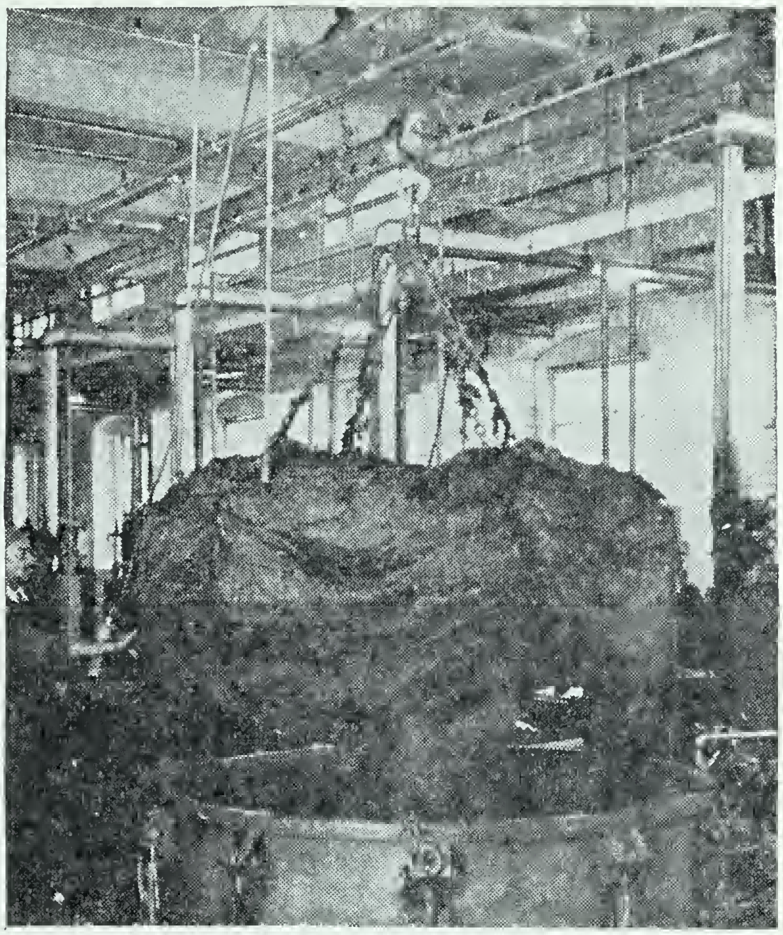
Two groups of acetate dyes are now used: (1) those that dye directly, and (2) those that require diazotizing and affixing agents in developing the color. Some of the earliest acetate dyes are known as S.R.A. dyes. This name was derived from "sulphoricinoleic," the acid that is required to make the dyes soluble in water.

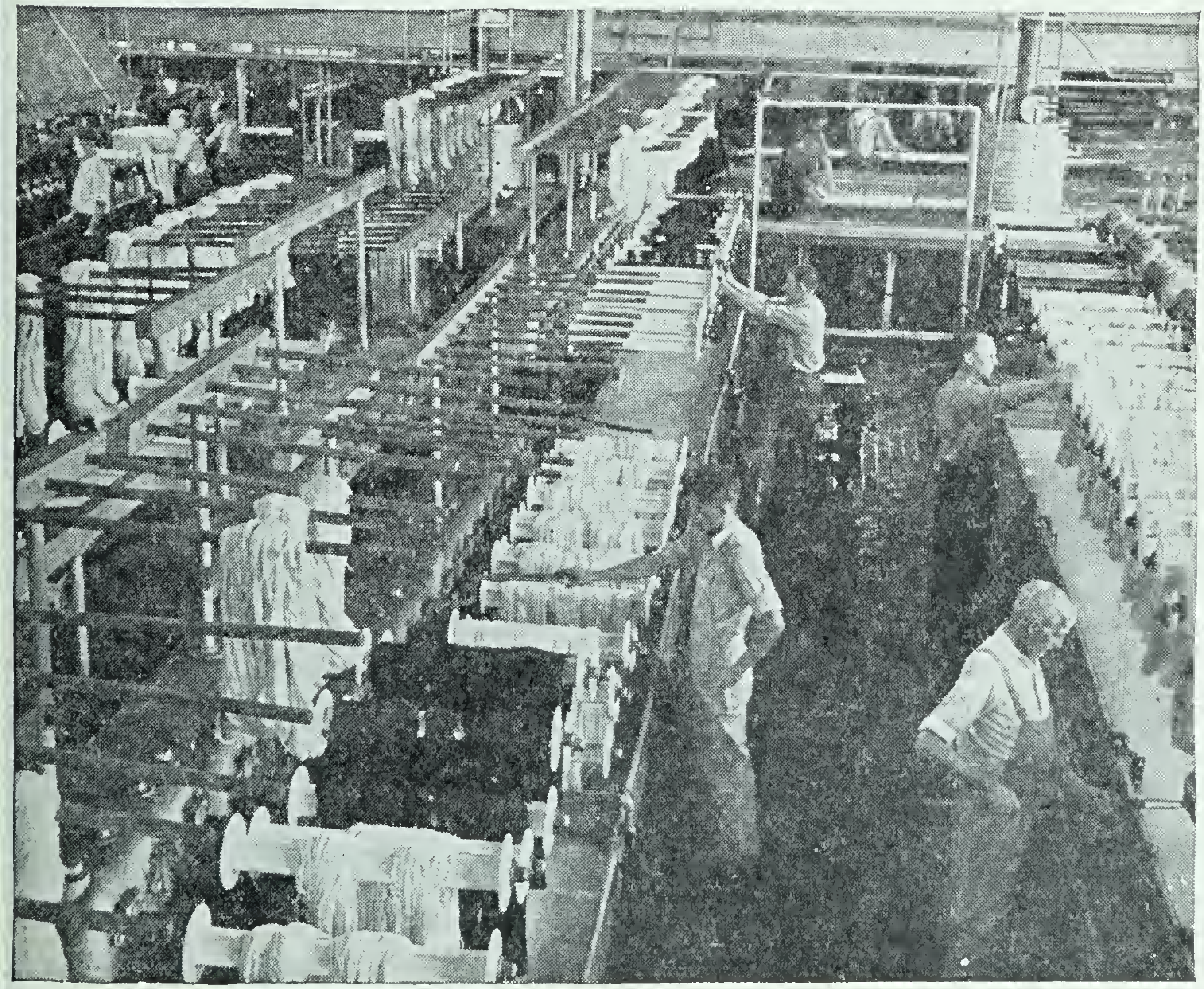
**Selection of Method of Dyeing.** Textiles may be dyed at any of the stages of their development from fiber into cloth. The methods may be summarized as follows:

1. Stock dyeing, in the fiber stage.
2. Yarn dyeing, after the fiber has been spun into yarn.
3. Piece dyeing, after the yarn has been constructed into cloth.
4. Cross dyeing, a combination of either stock dyeing or yarn dyeing, with subsequent piece dyeing.

*Right:* In stock dyeing, a mass of fiber is immersed in the dye bath.

*Below:* In one method of yarn dyeing, skeins of yarn are placed on racks and then lowered for complete immersion in the dye bath.





**Stock Dyeing.** In stock dyeing, the fibers are immersed in a dye bath, and the dyestuff is allowed to penetrate them. This method is considered most desirable because maximum penetration may be expected when material is in this form. A dye that penetrates to the center of a fiber will resist rubbing; therefore, stock-dyed fabrics are likely to be colorfast.

Yarns spun from dyed fibers are uniformly colored; if there is any irregularity of color, it is evened up in the subsequent carding, drawing-out, and spinning operations. Dyed fibers are more difficult to spin than undyed ones, however, because a degree of flexibility is lost in the dyeing process.

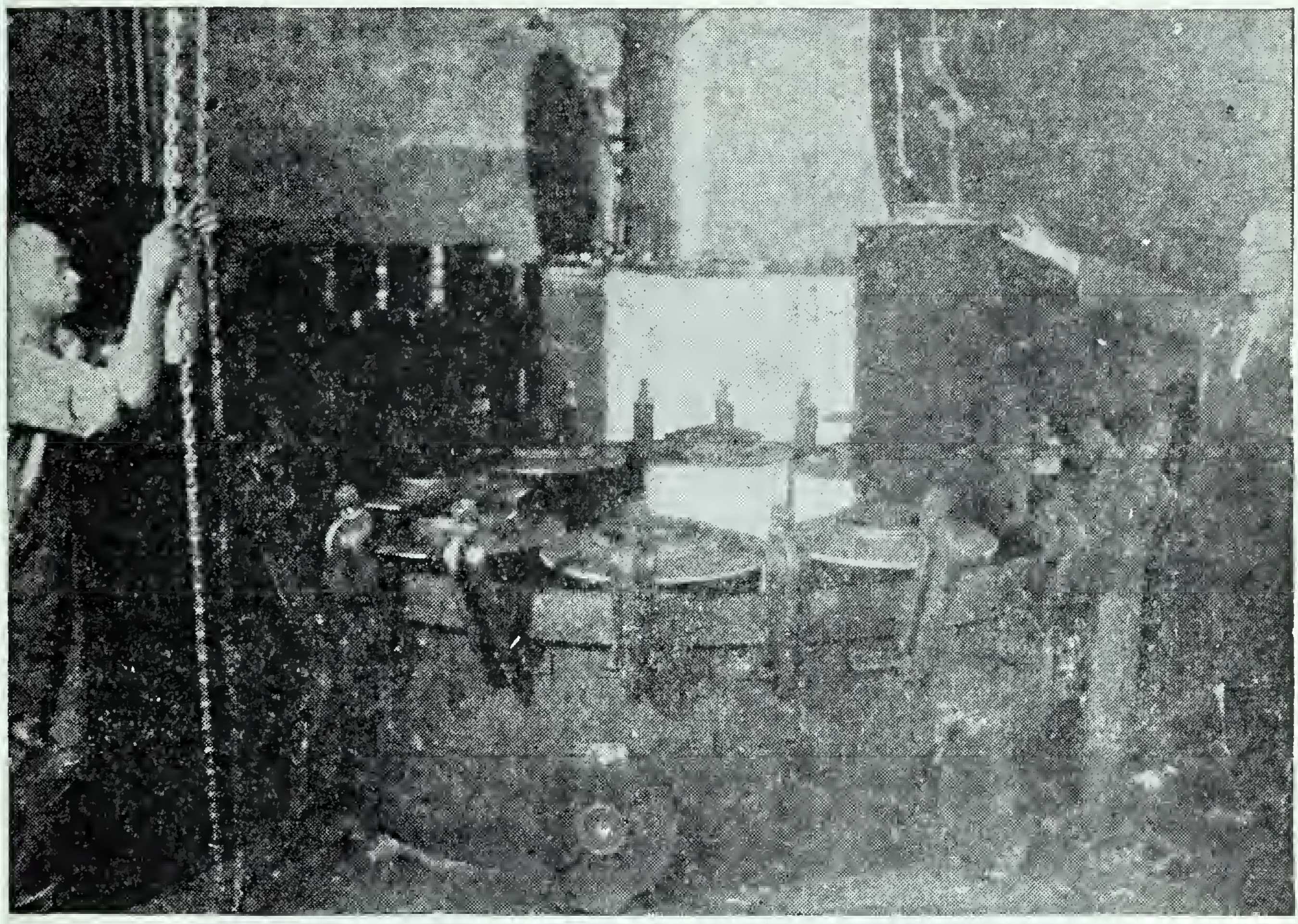
Wool is usually stock-dyed. The completeness of this method of dyeing is reflected in the expression, "dyed in the wool," which is used to attribute the quality of thoroughness.

Stock dyeing produces mixture effects and color blends, of which oxford suitings and tweed homespuns are examples.

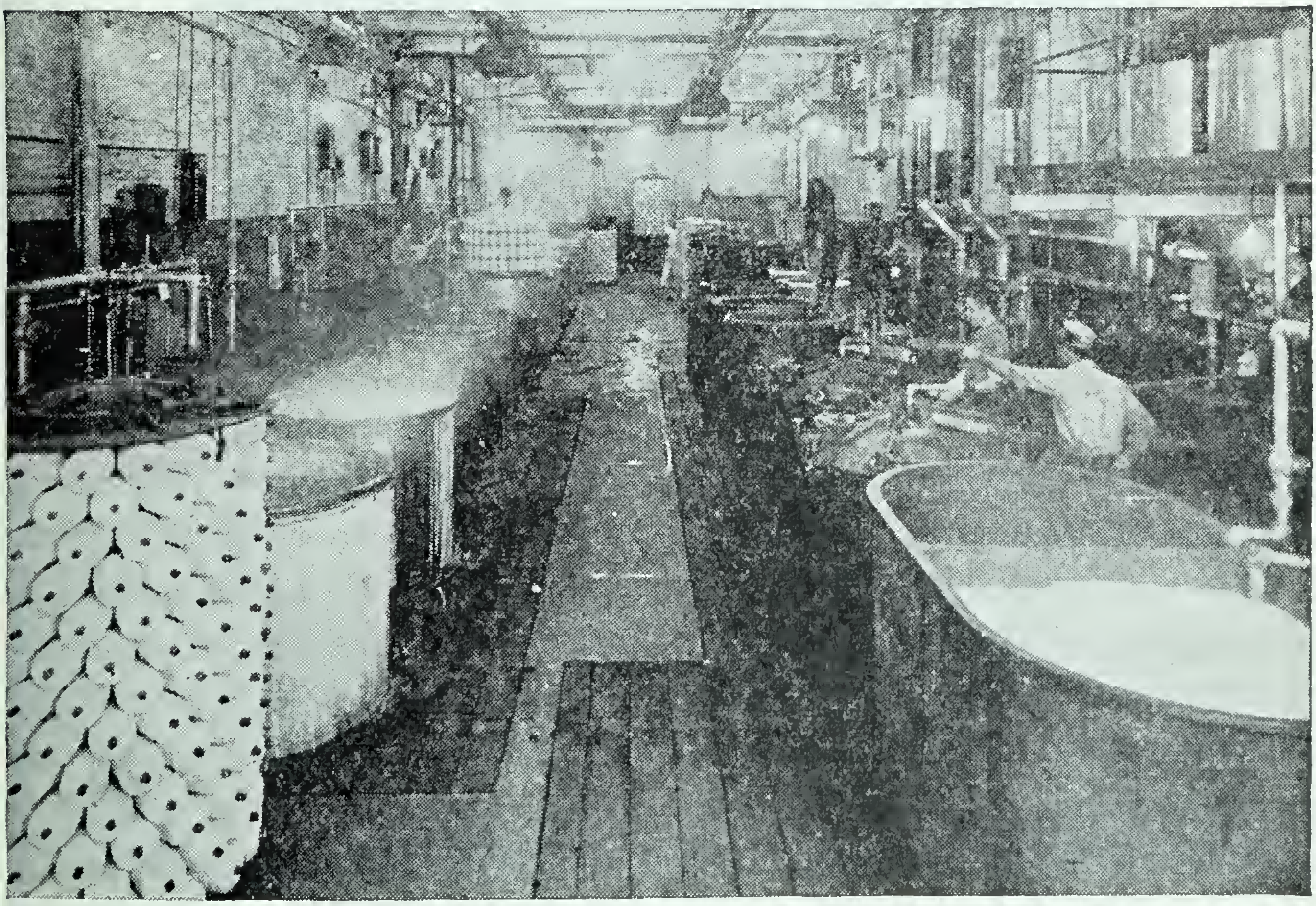
**Yarn Dyeing.** When dyeing is done after the fiber has been spun into yarn, the cloth is described as yarn-dyed. This method is also sometimes referred to as *skein dyeing*; the yarn is on spools or is in the form of skeins when immersed in the dye bath. The dyestuff has a chance to penetrate to the core of the yarn, similar to the penetration of the fiber in stock dyeing. Yarn-dyed fabrics are usually deeper and richer in color, and tend to be more colorfast than when the cloth is dyed after it is woven.

When yarns have been dyed separately, interesting color effects can be introduced into the weaving process by combining yarns of different colors. In such fabrics, the warp yarn is usually one color and the filling another color; examples of combinations of different-colored yarns are: checked gingham, striped percale, shepherd's check, plaid, chambray, seersucker, and heather mixtures.

**Piece Dyeing.** When cloth is dyed after it is woven, the process is called *piece dyeing,* sometimes *dip dyeing.* In piece-dyed fabrics, the dye does not penetrate and envelop the fibers or yarns as in stock dyeing or yarn dyeing. But this method is advantageous to the manufacturer because it permits him to keep his production close to changing fashion demands. When cloth is to be piece-dyed, it is woven "in the gray," and can be subsequently dyed to supply any current

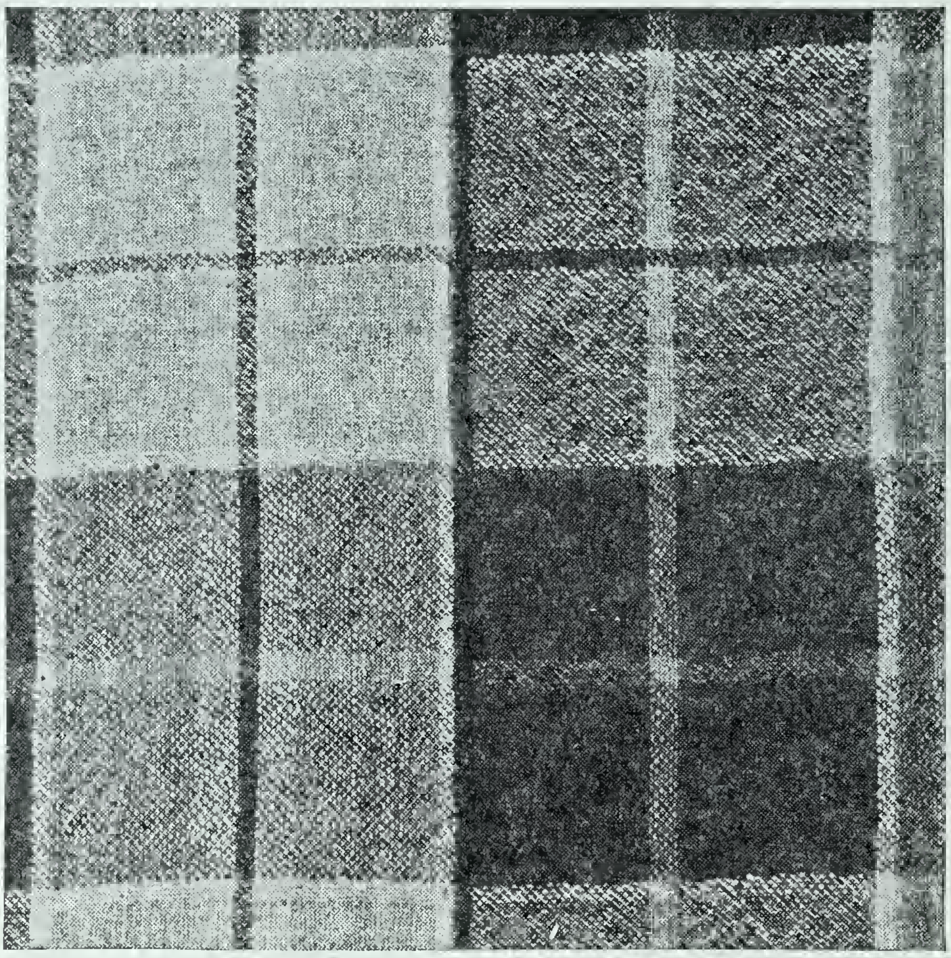


In beam dyeing (another form of yarn dyeing), the warp beam, on which the yarn has been wound ready for the loom, is immersed in the dye bath.



In package dyeing (another form of yarn dyeing), bobbins or cones of yarn on a single large rack (at left in picture) are immersed at one time in a huge vat.

seasonal color. This method is also economical because less dyestuff is required.



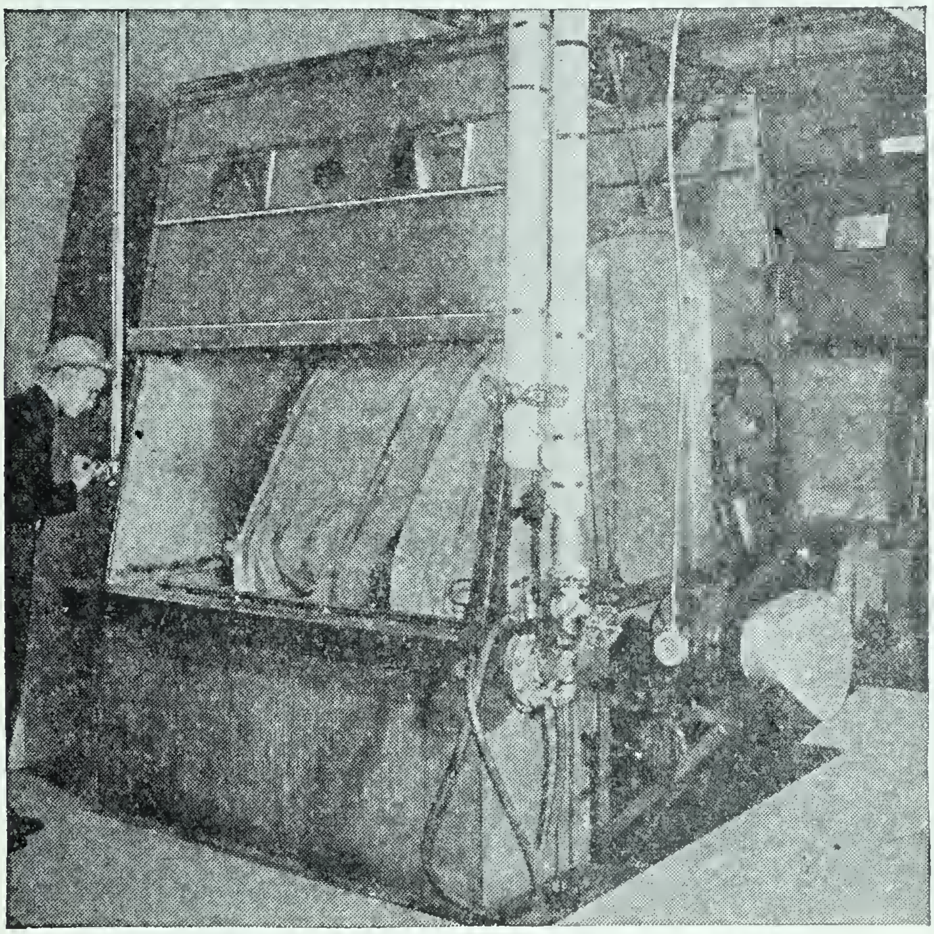
Plaids and ginghams are constructed of yarns dyed in the yarn stage.

Piece dyeing is limited to the production of solid colors, but two-color effects may be obtained by constructing the cloth of fibers or yarns that have been specially treated so as to take a deeper color, or to absorb no color at all.

From the point of view of the consumer, piece dyeing is the least desirable process because complete penetration does not take place, and the fabric may fade. When light spots show at frequent intervals, this is an indication that the fabric was piece-dyed; in this case, only the surface of the yarns took the dye. The consumer can generally detect piece dyeing by raveling and untwisting a single yarn, and examining the innermost part in order to see whether the dye has penetrated.

Piece dyeing is commonly used for the less expensive cotton fabrics. Linens, silk crepes, and sheer cottons such as organdy and voile are piece-dyed.

**Cross Dyeing.** Cross dyeing is a combination of stock dyeing or of yarn dyeing with subsequent piece dyeing. Cross dyeing produces varied effects. For instance, either the warp or the filling yarns may be stock-dyed or yarn-dyed, one set of yarns being left undyed. The cloth is piece-dyed after weaving; thus, color is given to the undyed yarn in a second dye bath, and the yarns that were originally stock-dyed or yarn-dyed acquire some additional coloring, which blends with the piece-dyed portion of the cloth.



Piece dyeing in a modern stainless-steel dye vat.

If yarns of vegetable fibers have been combined with yarns of animal fibers in a cloth that is to be piece-dyed, two separate dye baths must be used. The cloth must be dipped into both solutions, each of which affects the fiber for which it has an affinity. This affords a rich opportunity for colorful effects.

A mordant can be included in a single dye bath to cause the dye to adhere to the fiber for which it does not have an affinity. Thus, the more expensive method of cross dyeing, requiring two dye baths, need not be used.

Rayon fabrics containing both viscose and acetate yarns require two separate dye baths, as viscose and acetate will not take the same dye.

**Tests to Determine Colorfastness.** Beauty of color in any fabric is of no value to the consumer unless the dye may be considered fast under the conditions in which the fabric will be used. Color must meet such tests as washing, ironing, steaming, perspiration, strong light, and dry cleaning.

The United States Government tests fabrics for colorfastness in order to maintain and enforce trade standards. Retail stores often have laboratories for testing consumers' goods, to maintain merchandise standards for their own protection as well as to give their customers proper value for the price paid.

The consumer may also test fabrics for colorfastness at home. Some of the simple tests are well worth while, as garments will give additional wear and retain a fresh, new appearance if samples of the fabrics are tested before the garments are subjected to cleaning at home or at commercial laundries or dry cleaners.

*Fastness to Washing.* The usual method for determining fastness to washing is to wash a sample of the fabric, and to iron the sample while it is still wet under a white cloth. If the dye bleeds on the white cloth, the color cannot be considered fast. Home washing is not a rigorous enough test for fabrics that will be washed in commercial laundries. For such, a more adequate test is to immerse the sample in water containing Clorox or in Javelle water, because similar strong compounds are used in the laundries.

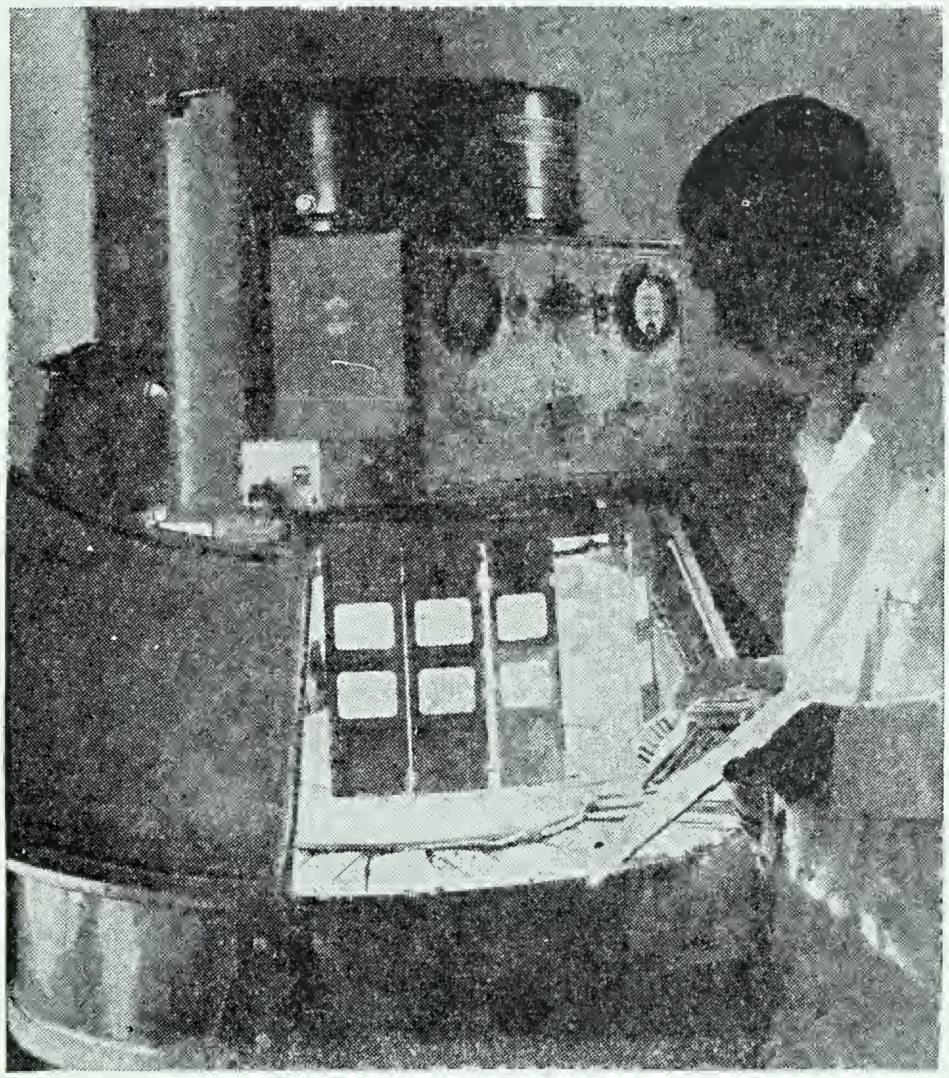
*Fastness to Ironing.* To test for fastness to ironing, iron the sample with a very hot iron. After the sample has cooled, compare it with the original fabric. If the color is unchanged, the fabric is fast to ironing.

*Fastness to Steaming.* To test for fastness to steaming, place a sample between the folds of a white cloth and steam it over a teakettle. If the color is fast, it should be unchanged, and no dye will show on the white cloth.

*Fastness to Light.* To test for fastness to light, cover half of a sample of fabric with opaque paper and expose the sample to outdoor light for perhaps twenty days; then compare both halves. If the exposed portion shows a perceptible fading, the fabric is not fast to light.

It is not possible to give a more specific period of time for exposure because the intensity of sunlight varies in different localities. Usually, resistance to an exposure of twenty days is considered good.

This test is performed in a much shorter time in textile testing laboratories by the use of the Fade-Ometer, an apparatus having very strong electric lamps or a special carbon arc light. If a fabric can withstand an exposure of forty hours in this machine with no perceptible loss of color, it is said to have superlative fastness to light. A fabric has good fastness to light if it withstands an exposure of thirty hours.



The Fade-Ometer is used for testing colorfastness to sunlight. Samples of fabric are placed between slides and are exposed to the rays of a sun lamp for a period of hours or days. After removal, the samples are compared with an unexposed piece of fabric to determine the extent of loss of color.

*Fastness to Perspiration.* To test for fastness to perspiration, soak a sample of the dyed fabric for ten minutes in a weak acid, such as a dilute acetic acid solution. Do not rinse. Roll the sample in a piece of undyed cloth. Permit gradual drying, and leave the material rolled for a few days. If comparison with the original color shows that the shade of the dyed fabric has changed, or if the dye appears on the cloth in which the sample was rolled, the color is not fast to perspiration.

The effects of both acid and alkaline perspiration can be determined by the standard Government test, which recommends the use of two solutions. *For acid perspiration:* 10 grams sodium chloride; 1 gram lactic acid, U.S.P. 85 per cent; 1 gram disodium orthophosphate, anhydrous. Make up to 1 liter with water. *For alkaline perspiration:* 10 grams sodium chloride; 4 grams ammonium carbonate, U.S.P.; 1 gram disodium orthophosphate, anhydrous. Make up to 1 liter with water.

ARTIFICIAL DYES USED FOR THE MAJOR FIBERS

| Dye | Cotton | Linen | Regenerated Rayons | Wool | Silk | Acetate Rayon |
|---|---|---|---|---|---|---|
| ACID | ...... | ...... | ........... | X | X | ...... |
| BASIC | ...... | ...... | ........... | X | X | ...... |
| CHROME | ...... | ...... | ........... | X | ...... | ...... |
| DIRECT | X | X | X | ...... | ...... | ...... |
| DEVELOPED | X | X | X | ...... | ...... | ...... |
| SULPHUR | X | X | X | ...... | ...... | ...... |
| VAT | X | X | X | ...... | ...... | ...... |
| NAPHTHOL | X | ...... | X | ...... | ...... | ...... |
| S.R.A. | ...... | ...... | ........... | ...... | ...... | X |

ARTIFICIAL DYES RANKED BY COST AND DEGREE OF FASTNESS [1]

| | Type of Dye | Home Washing | Commercial Laundry | Light | Slashing | Bleaching (Chlorine) | Cross Dyeing | Mercerizing |
|---|---|---|---|---|---|---|---|---|
| 1 | DIRECT | Good in light shades; poor in heavy shades | Poor | Some poor, some good | Good in light shades; heavy shades require care | Bad | Bad | Some good |
| 2 | BASIC | Poor | Bad | Bad | Require extreme care | Bad | Bad | Bad |
| 3 | SULPHUR | Good | Fair to poor | Good | Excellent | Bad | Good | Good |
| 4 | DEVELOPED | Good | Fair to poor | Poor | Excellent | Bad | Good | Good |
| 5 | NAPHTHOL | Excellent | Excellent | Very good | Excellent | Excellent (not good to peroxide) | Excellent | Excellent |
| 6 | VAT | Excellent | Excellent | Excellent | Excellent | Excellent | Excellent | Excellent |

Samples of the dyed fabric are placed against pieces of undyed cloth and left for a few days in each solution. The samples of dyed fabric and undyed cloth are then squeezed and allowed to dry. Any indication of staining denotes poor fastness to perspiration.

*Fastness to Crocking.* To test for fastness to crocking, rub a dry sample against a white cloth; make the same test with a wet sample. If the color does not rub off on the white cloth, the color is fast to rubbing or crocking.

*Fastness to Gas Fading.* Flames from heating appliances cause nitrogen in the atmosphere to unite with oxygen, forming nitrogenous compounds that cause some acetate dyes to lose color if the fumes come in contact with the fabric. This is known as gas fading or acid fading in acetate rayons; blue is especially susceptible. An antifume finish of an alkaline nature can be applied to a fabric to minimize gas fading. This is accomplished by the use of an inhibiter in the dye.

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[1] Courtesy Franklin Process Co. No. 1 indicates the less expensive dyes; No. 6 the more expensive dyes.

Fabrics can be tested to determine the permanency of their antifume finish by exposure for about twenty hours in a chamber containing the combustible fumes of a gas burner.

*Test yourself on this chapter by answering these questions:*

1. What are the essential differences between stock, yarn, and piece dyeing?
2. Explain the importance of dyeing from the consumer's point of view.
3. What is vat dyeing? When would it be used?
4. Discuss both the limitations and the advantages of direct dyes.
5. Discuss the advantages and the limitations of acid dyes.
6. When is cross dyeing used?
7. Explain the following terms: fugitive, crocking, bleeding, gas fading.
8. What is a mordant? Explain how this can be used to replace one method of dyeing.
9. Why are warp yarns dyed in the fiber stage or in the yarn stage, instead of using the piece-dyeing method entirely?
10. What two factors enter into the selection of a dye?
11. What type of fabrics need to be colorfast to washing? To light? To perspiration?
12. What kinds of dyes are used for the animal fibers? For the vegetable fibers? For man-made fibers?
13. Why is salt often put into a dye bath?
14. What happens to sulphur-dyed fabrics if they are stored for a great length of time?
15. Why are direct dyes the least desirable for the general consumer?
16. Why are vat-dyed fabrics the most desirable for the general consumer?
17. Why are natural dyes no longer used in quantity in the dyeing industry?
18. What characteristic is common to yarn dyeing, skein dyeing, and beam dyeing?
19. What factors determine the durability of a dye?

20. Explain the difference between dyeing and printing.

21. Describe briefly the methods and stages of dyeing.

22. Explain how to test colorfastness: (*a*) to light, (*b*) to washing, (*c*) to crocking.

## Suggested Readings

Dooley, W. H., *Textiles,* Chapter 8.
Evans, M., and McGowan, E. B., *A Guide to Textiles.*
Hess, K. P., *Textile Fibers and Their Use,* Chapter 4, Section 1.
Matthews, J. M., *Application of Dyestuffs to Textiles.*
Nystrom, P. H., *Textiles,* Chapters 21, 22.
Pellew, C. E., *Dyes and Dyeing.*
Watson, W., *Textile Design and Color.*
Wingate, I. B., *Textile Fabrics,* Chapter 13.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 13.

## CHAPTER VII

# DECORATION WITH COLOR DESIGN

The spinning process produces yarns of different sizes; linenlike yarns with nubby effects; slub yarns; and a variety of complex yarns, such as bouclé and ratiné. All these yarns are used to create some form of decoration in cloth. In the subsequent weaving process, decoration is also obtained by the patterns of the weaves. The checkerboard pattern of the plain weave, the variations of the basket construction, the diagonal of the twill weave, and the luster of the satin weave produce simple designs. This type of decoration becomes more elaborate as cloth construction advances to the use of the third dimension in the pile weave; to the open-mesh, lacelike effect of the lappet; and to the intricate effects of the Jacquard weave that appear in damask, brocade, and brocatelle fabrics.

When cloth passes through finishing operations, it is given lustrous effects by mercerizing, sizing, schreinerizing, calendering, beetling, or moiréeing, all of which contribute something to the final appearance of the fabric. Other finishing processes create the additional effects of soft napped surfaces and the crinkled designs seen in seersucker, matelassé, and similar crepes.

Dyeing makes an important contribution to cloth decoration by means of the many beautiful colors it produces and the color harmonies that may be obtained by combinations of the various dyeing methods.

All the foregoing decorative effects are obtained at various stages of construction of the cloth—some at the fiber stage, others during the spinning and weaving processes, still others during the finishing and dyeing processes.

**Methods of Decoration with Color.** Decoration in the form of color can be applied after the fabric has been otherwise finished. One such form of decoration is called *printing*. Cloth that is to be printed must be singed, bleached, and cleaned.

The methods of decoration that produce color designs are:

1. Block printing
2. Roller printing
3. Discharge or extract printing
4. Resist printing
5. Stencil printing
6. Screen printing
7. Warp printing
8. Batik dyeing
9. Tie dyeing
10. Composition or paste designs
11. Spray painting

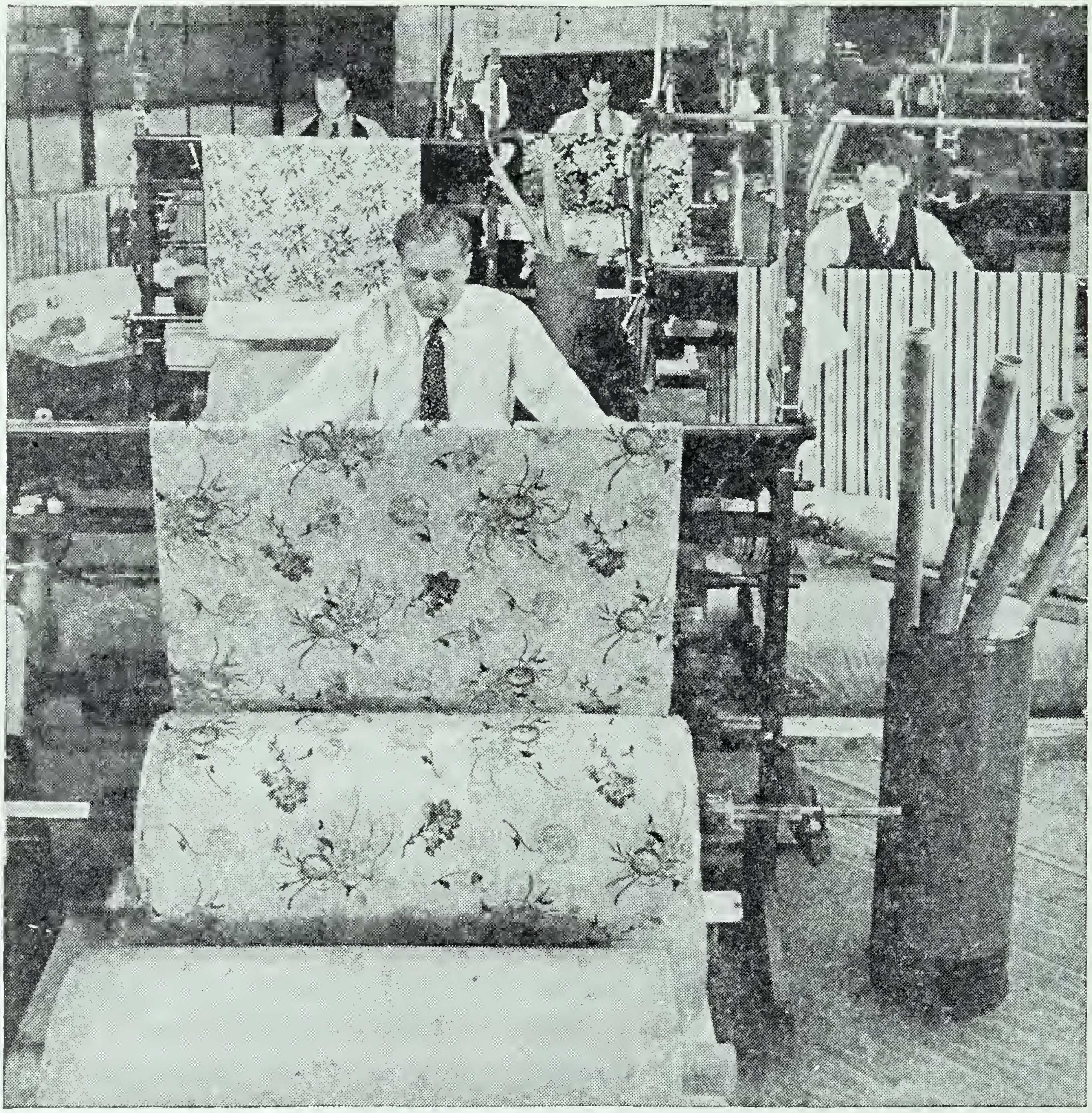
In most of these methods, the dye is imprinted on the cloth in paste form, and any desired pattern may be produced. Paste dyes require a sizing, such as cornstarch or wheat starch, which acts as a binder. In this method of applying color, thorough penetration of the dye is not necessary.

**Distinguishing Printing from Dyeing.** When the consumer wishes to decide whether a fabric has been dyed by immersion or whether the color has merely been printed on the cloth, he may note the outline of the design. On the printed fabric, the outline or edges of the design will be sharply defined on the right side of the cloth, and the entire design will seldom have penetrated to the wrong side.

On sheer fabrics the design may show up favorably on the reverse side because any dyestuff will penetrate sheer construction. If such fabrics intentionally simulate woven designs, which use yarn-dyed warp and filling, the consumer may detect this by examining some of the raveled yarns. If the design has been imprinted, the yarns will show areas on which the color is not equally distributed.

**Block Printing.** The oldest method of printing designs on cloth is the hand method called block printing. This method is not commercially important because it is too slow—printed cloth cannot be produced inexpensively in large enough quantities by the hand-blocked method. Block printing has usually been done in countries where labor is less costly than it is in the United States. Today, cloth is block-printed only in comparatively short lengths of material. Block printing is found chiefly in decorative pieces for the home or in expensive linens for upholstery purposes.

To make hand-blocked prints, the design must first be carved on a wooden or metal block. The dyestuff is applied in paste form to the design on the face of the block. The block is pressed down firmly by



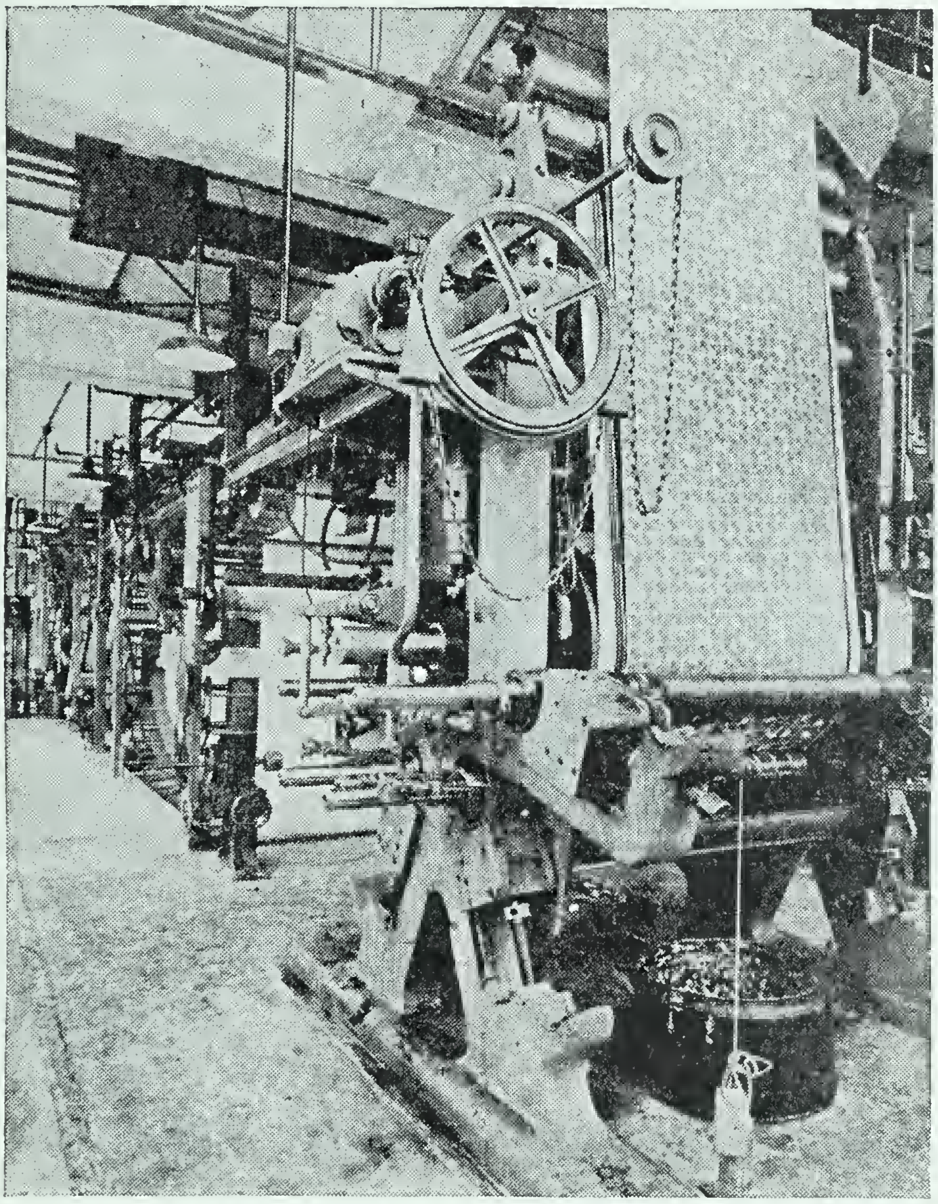
Machine-printed fabrics.

hand on selected portions of the surface of the fabric, imprinting the carved design as many times as desired on a specific length of cloth.

To obtain variation of color in the same design, as many additional blocks must be carved as there will be additional colors; the portions of the design that will appear in different colors must be separately imprinted by hand before each design is complete. The more colors used, the more valuable and expensive the hand-blocked print will be, because of the enhanced beauty of design as well as the labor involved in the hand printing.

The consumer can recognize hand-blocked prints by noting slight irregularities in the detail of the design as well as repetition of the design and by comparing areas where slight variations in color are manifested. Even the irregularities are imitated by machine printing, however, in order to give machine prints the characteristic appearance of expensive hand-blocked prints.

**Roller Printing.** The machine method of printing designs on cloth turns out color-designed fabrics in vast quantities at the rate of thousands of yards an hour. This method of producing attractive designs is relatively inexpensive when compared with any hand method. It is a machine counterpart of block printing.

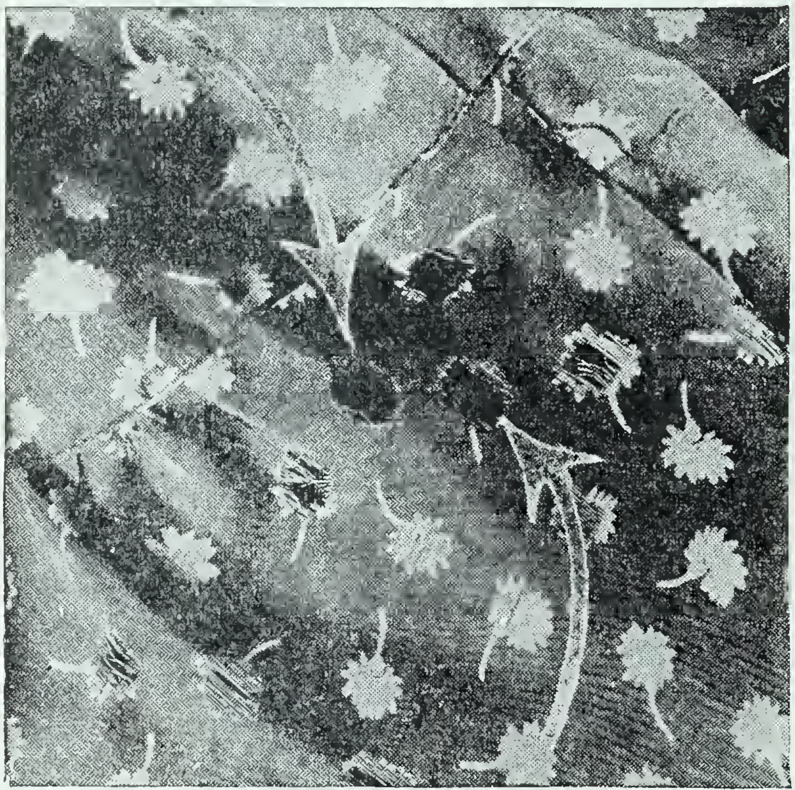


By this modern printing machine, fabrics are printed under controlled tension.

In roller printing, engraved copper cylinders or rollers take the place of the hand-carved blocks. Just as there must be a separate block for each color in block printing, so must there be as many engraved rollers in machine printing as there are colors in the design to be imprinted on the cloth.

Each of the engraved rollers first comes in contact with a companion roller that has been submerged in the dye paste to be used for its part of the design. A sharp blade, called the doctor blade, scrapes the dye from the part of the roller upon which there is no design, so that other portions of the cloth will not come in contact with the dyestuff. As the cloth passes between the engraved rollers, the design is imprinted on the fabric. A mordant is generally used in the dye paste to fix the color.

Machine-printed fabrics are sometimes printed on both sides of the cloth; thus, equally clear outlines appear on both the right and the wrong side. This is called *duplex printing.* The design is applied so skillfully by careful registration of the printing cylinders that the result may be mistaken for a woven design, but the difference can be easily detected by raveling a yarn.



This fabric was discharge-printed. The chemical used to bleach the design on the fabric was too strong, causing the design area to deteriorate.

*Blotch Prints.* Blotch prints may have a colored background as well as a colored design. Both may be printed at the same time. This method is used chiefly for cottons and linens.

**Discharge or Extract Printing.** The discharge or extract method of printing cloth receives its name from the fact that color is discharged or extracted from fabric that has first been piece-dyed. Because of the intention to extract the color, basic or direct dyes, which can be easily removed, are used. The chemical that discharges the dye tends to weaken the cloth in the area of the design.

Because the background dye is not fast and the cloth may be weak in parts, the consumer should not buy fabrics that have been printed by the discharge method if he wants a serviceable and durable fabric. Discharge prints are found in cottons and rayons, and in some patterned silks with dark backgrounds.

In extract printing, the cloth is put through rollers that exude a bleaching agent, such as zinc oxide paste or hydrosulphite, in the form of a small pattern, reproducing it on the cloth by bleaching the dye. This method is chiefly employed where a light design is required against a dark background, because the bleaching produces an off-white color in the design. A light polka-dot pattern on a dark ground is an example of discharge printing.

**Resist Printing.** In resist printing, bleached goods are run through cylinders that stamp a pattern on the cloth in the form of a resist paste, a resinous substance that cannot be penetrated when the cloth is subsequently immersed in a dye. The dye will affect only the parts of the cloth that are not covered by the resist paste. After the fabric has passed through a subsequent dyeing process, the resist paste is removed, leaving a pattern on a dark ground.

In the discharge method, cloth is first dyed and the color is then extracted by an imprinted chemical; in the resist method, a resist paste is first imprinted and the fabric is then dyed. The durability of the fabric is not affected by the resist method.

**Stencil Printing.** Stencil printing originated in Japan. Its high cost limits its use and importance in the United States. In stencil printing, the design must first be cut in cardboard, wood, or metal. The stencil may have a fine, delicate design; or there may be large spaces through which a great amount of color can be applied. A stencil design is usually limited to the application of only one color and is generally used for narrow widths of fabric.

**Screen Printing.** The chief advantage of screen printing is individuality of design. The method is especially adapted for printing large designs having elaborate effects. The expense of the process limits its use to the printing of comparatively short yardages. The process is not used for mass production.

In screen printing, the design is drawn on an intermediary cloth or screen, which serves as a stencil. A lacquer coating is applied to all parts of the underside of the screen on which the design does not appear. The fabric and the screen are fastened to a frame, and the dye is brushed on the screen by a hand roller. The dye penetrates through the design, thus imprinting the pattern on the fabric. A separate screen is required for each color.

In screen printing, it is possible to have designs consisting of squares, circles, and ovals because the areas not to receive the dye are painted out by the lacquer. If clearly defined geometric designs were attempted in cardboard or metal stencils, obviously, the cut area would fall away.

On a knitted fabric such as jersey, screen printing is the only printing method that can be used; other methods smear the dye, as a knitted fabric stretches when it receives the impact of the rollers.

**Warp Printing.** Warp printing is roller printing applied to warp yarns before they are woven into cloth. White or neutral-colored filling threads are then used in the weaving process. This method produces designs with soft, nebulous, but striking, effects. Fine filling yarns are generally used so that the design on the warp will not be obscured. Great care must be taken to keep the warp yarns in their proper position so the outline of the design will be preserved. Warp printing is used for expensive cretonnes and upholstery fabrics.

**Batik Dyeing.** The hand method of producing designs known as batik originated in Java. It enjoys frequent renewal of popularity in the United States. Batik is somewhat similar to the machine method of resist printing.

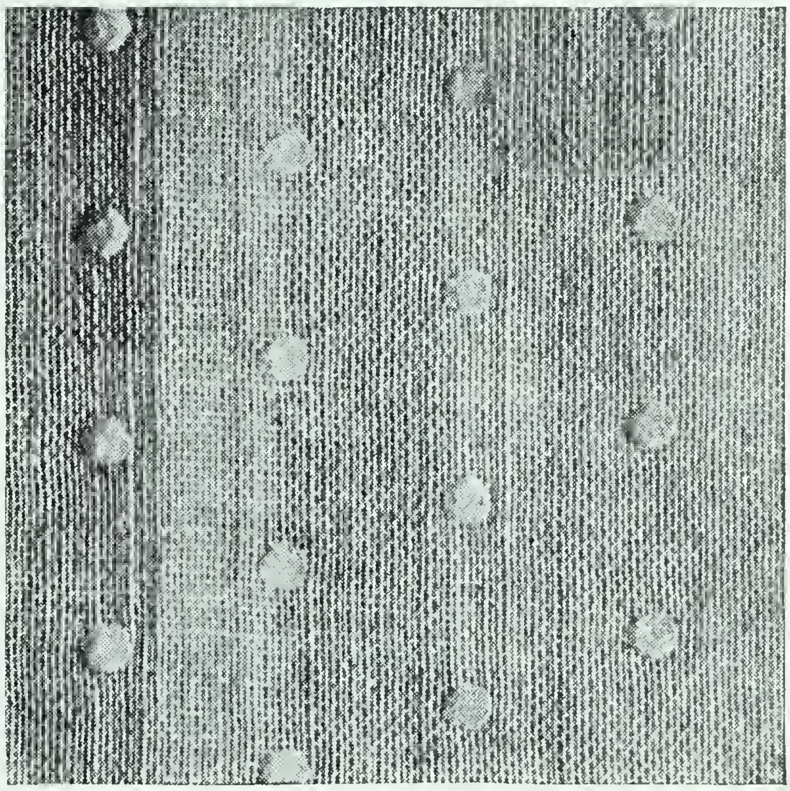
The design is drawn on the fabric, and beeswax containing paraffin is deposited through a small cup-shaped instrument on the areas that are not to be colored. The fabric is then immersed in a tepid dye bath, and the wax resists penetration of the dye. After the cloth is dried, the wax is removed by applying heat or benzine. The result is a silhouette design on a dyed background. The process is repeated if additional colors are to be added.

Sometimes, in the last application of color, the wax is permitted to crack, and the last dyestuff partially penetrates the other dyed portions, producing the multicolored design characteristic of batik. The American method differs from the oriental in that light colors are applied first, followed by the wax; then the deeper shades are built in. In the oriental method, the dark shades are applied first, and the portions to be kept light are waxed.

**Tie Dyeing.** The results of tie dyeing are similar to batik, but the designs can be only circular in form, as the dye is resisted by knots that are tied in the cloth before it is immersed in the dye bath. The outside of the knotted portion is dyed, but the inside is not penetrated if the knot is firmly tied.

Partial penetration occurs when the knot is not tight, causing gradations and irregularities of color that produce indistinct but attractive designs. The process is repeated as many times as desired by making new knots in other parts of the cloth and immersing the fabric in additional dye baths. This gives a characteristic blurred or mottled effect, which is the result of the dyes running into each other.

Like other hand methods of decorating cloth, tie dyeing is expensive. Because the method creates interesting designs, the patterns are duplicated in roller printing.



Pasted designs, like the dots in this fabric, may disappear in laundering.

**Composition or Pasted Designs.** The rollers or cylinders that are used to imprint color by the means of dyes, chemicals, and resist pastes can also apply lacquer or colored paste to cloth as small designs. Such designs are called *flocked dots.* Considering the fact that the dots are only glued on, this method is surprisingly lasting. It is not used on fabrics that are expected to withstand laundering, however. Even for the dry cleaner, it presents a problem.

Substances that can be baked into the fabric are also used for this decorative effect. When this is done, the designs become so much a part of the cloth that they may be considered permanent, seldom being destroyed by washing or dry cleaning.

**Spray Painting.** Designs may be hand painted on cloth, or the dye may be applied with a mechanized airbrush, which blows or sprays color on the fabric. Spray painting is used when surface coloring is to be done quickly and economically: for example, designs on tablecloths. The type of dyestuff used may be direct, acid, or vat dyes dissolved in water, alcohol, or other organic solvent.

Decoration of Cloth by Printing and Dyeing

| Type of Decoration | Hand Method | Machine Method |
|---|---|---|
| Block Printing | Design carved on blocks; dye applied to block; block pressed on fabric | |
| Roller Printing | | Design etched on roller; companion roller transmits dye to etched roller, which transmits it to fabric |
| Discharge Printing | | Bleached goods first dyed; chemical bleach printed on fabric; color discharged |
| Resist Printing | | Resist paste put on fabric; fabric dyed; resist paste removed |
| Stencil Printing | Design cut in stencil; color applied over stencil | |
| Screen Printing | Design sketched on silk voile to be used as screen; lacquer applied to background of design; color applied to screen as a stencil; roller forces color through screen | |
| Warp Printing | | Engraved rollers print design only on warp yarns; fabric then woven, using white or neutral filling yarn |
| Batik Dyeing | Design put on fabric; wax deposited on background of design; fabric dyed; wax removed | |
| Tie Dyeing | Cloth knotted or tied in parts with string; dipped into dye; cloth untied | |
| Composition or Paste Designs | | Lacquer figures or colored paste glued or baked on surface of cloth |
| Spray Painting | Mechanized airbrush applies surface coating | |

*Test yourself on this chapter by answering these questions:*

1. Define these terms: blotch prints, duplex printing, stenciling.
2. Differentiate between discharge and resist printing.
3. Describe warp printing and its result.
4. Compare and contrast the batik method and the resist method of decoration.
5. Describe tie dyeing, and explain why it is expensive.
6. What is meant by block printing?
7. What are the several methods of hand decoration with color?
8. Why are most fabrics machine-printed?
9. How could one determine whether a color design is printed or woven?
10. Name and describe five types of printing on fabrics.
11. How do screen printing and stenciling differ?
12. What are the characteristics of a well-printed fabric?
13. How can spinning and weaving processes produce decoration in fabrics? Finishing processes?
14. Why is the discharge-printed fabric the least desirable?
15. What is the difference between a blotch and a duplex print?

## Suggested Readings

Bray, H. A., *Textile Fibers, Yarns and Fabrics,* Chapter 17.
Hess, K. P., *Textile Fibers and Their Use,* Chapter 5, Section 1.
Pellew, C. E., *Dyes and Dyeing.*
Small, C. P., *How to Know Textiles,* Chapter 9.
Wingate, I. B., *Textile Fabrics,* Chapter 13.

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## CHAPTER VIII

# COTTON: UNIVERSAL AND ECONOMICAL

Ancient historical records show that cotton was first cultivated in oriental countries at least three thousand years ago. India is believed to be the oldest cotton-growing country. Cotton was known and used in all the Mediterranean countries, being introduced into Italy by the Arabs and into other parts of Europe by the Crusaders. The use of cotton is mentioned in England in writings of the thirteenth century, although its use did not become general until the first half of the sixteenth century.

In the United States, cotton was cultivated in the early seventeenth century. The impetus of the Industrial Revolution, represented in the cotton industry by the invention of the spinning frame and the spinning mule in England, and by the invention of the cotton gin in the United States, resulted in vastly increased cotton production and manufacturing. Today, cotton fields extend across the southern section of the United States from Virginia to California.

Because cotton fabrics have been so well known and so extensively used throughout the world for hundreds of years, the spinning of the cotton fiber into yarn, the weaving of cotton yarn into cloth, and even many of the finishing processes used for cotton goods come first to mind and naturally serve as foremost examples in a study of fiber and fabric.

Cotton has been of service to mankind for so long that its versatility is almost unlimited. New uses for cotton are constantly being discovered. Cotton is considered nature's most economical fiber; it is low priced as a raw material and as a finished product. It can be depended on to serve many purposes. Not only is cotton a textile fabric in its own right, but its by-products form the base for some of the man-made textile fibers.

Cotton plant, bolls, and a bale of cotton fiber after cleaning and compression in a modern gin.

**World Production of Cotton.** Today, the United States produces the bulk of the world's supply of cotton. The importance of cotton to this country as well as to the rest of the world can be readily comprehended from the following statistics of the United States Department of Agriculture—representative comparative figures for a normal year.

World Production of Cotton by Bales (1940)
(Prepared in 1941)

| | | | |
|---|---|---|---|
| Total world production | 30,230,000 | China | 2,354,000 |
| United States | 12,566,000 | Egypt | 1,900,000 |
| India | 4,841,000 | Peru | 383,000 |
| USSR | 3,000,000 | Mexico | 288,000 |
| Brazil | 2,464,000 | Argentina | 235,000 |

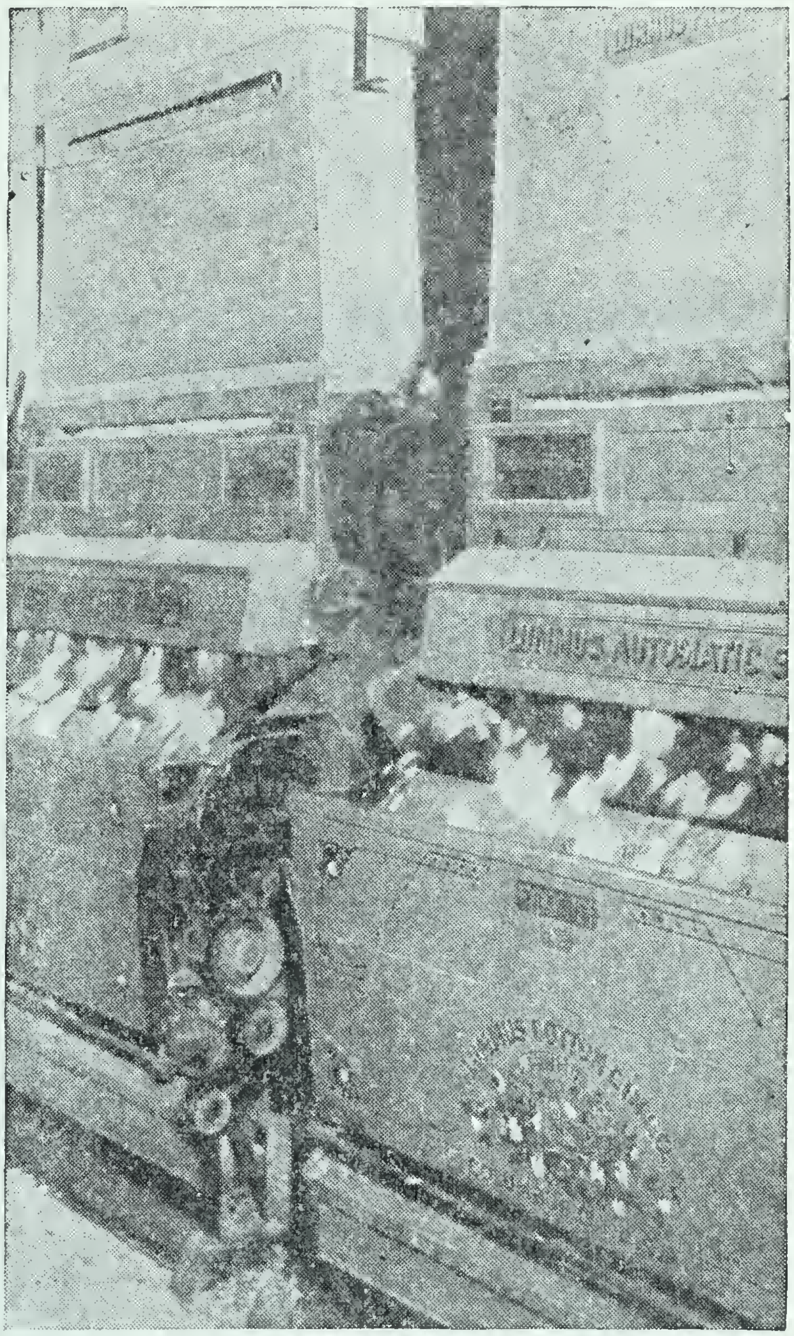
**Cultivation of Cotton.** Cotton can be cultivated only in warm places, which, of course, is the reason for its cultivation in the southern part of the United States. Cotton requires about two hundred days of continuous warm weather with adequate moisture and sunlight; frost is harmful to the plant. The ground must be thoroughly plowed, and the soil pulverized.

Cotton is picked by hand. The amount of care used in picking and handling the bolls affects the grade.

In the United States, usually in March or April, carefully selected cotton seeds are planted in rows. Approximately thirty-five days pass before the seeds develop. The plants require careful fertilization. When they are about 3 inches high, they are weeded and thinned out.

The cotton plant begins to bloom in June or July, about four months after planting. First, creamy-white blossoms appear. These change to a reddish purple in about two days and fall off, leaving seed pods that grow to full size by August or September, about a month after the blossoms first appeared. Before maturing, the cotton bolls must be protected against the boll weevil, which is attracted to the plant at this stage.

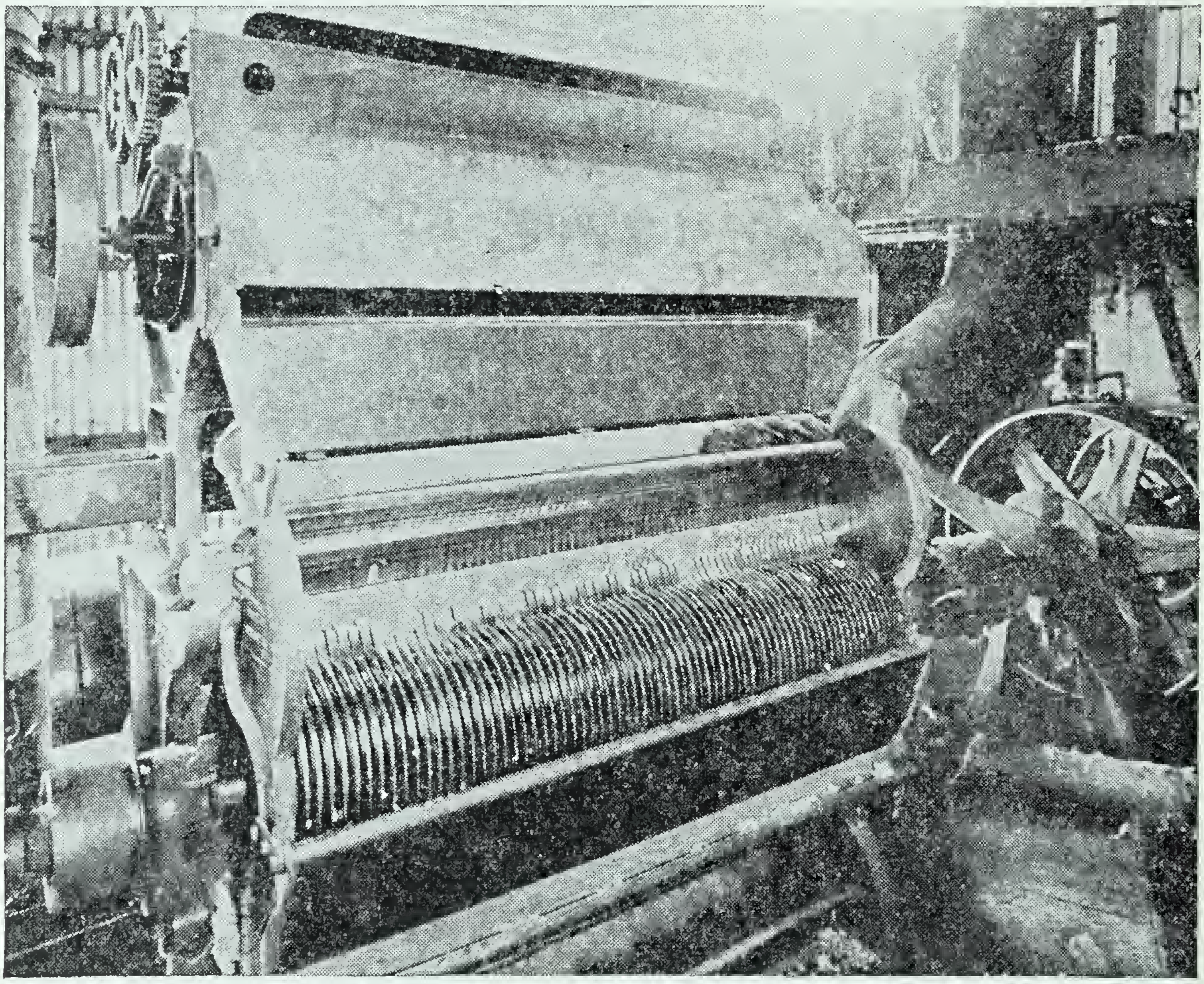
When fully grown, the cotton plant may be from 3 to 6 feet in height. Its wide green leaves conceal some of the bolls, which begin to burst with fleecy white cotton fiber. This indicates that the cotton is ready for harvesting.



Cotton fiber, which has entered the top of the cotton gin from a pneumatic conveyor, is here seen falling on covered gin saws after sand and coarse soil have been removed. The saws separate the seeds from the fiber. The fiber is removed from the saw teeth by a blast of air and is whisked toward the back. The seed falls into a conveyor at the bottom of the machine.

*Harvesting.* Not all cotton bolls open at the same time. Only those that burst, thus exposing the fiber, are ready for picking. A cotton field must be gone over several times. Consequently, harvesting the cotton fiber requires a large amount of labor as picking is done by hand. The picking is the most expensive operation in cotton production.

Although no mechanical picker has been found practical for widespread use, a machine picker has been developed that can pick cotton from plants 2 to 4½ feet in height. The mechanical picker, however, represents a large capital investment for the owner of a comparatively small cotton tract. A co-operatively owned one may prove to be economical.



The inside of a cotton gin, showing the grids and saws.

**Ginning and Baling.** When the raw cotton is harvested, it contains seeds, leaf fragments, dirt, and other material that must be removed before the fiber can be baled. Cotton seeds alone constitute approximately two-thirds of the weight of the raw cotton when first picked. The seeds are removed by the cotton gin, a machine having rows of revolving saw-toothed bands that pull the fiber away from the seeds as well as remove other extraneous material. The cotton seeds are one of the valued by-products.

The cotton fiber is compressed into rectangular bales, which are then covered with jute bagging and bound with iron bands. These bales weigh about 500 pounds each.

**By-products of Cotton.** The raw cotton passes through several cleaning processes before it is baled as well as after it is unbaled at the cotton mill. As a result, the grower obtains valuable by-products that amount approximately to one-sixth of the entire income derived from the cotton plant. Cotton is therefore important because of its contributions to other industries as well as to the textile industry.

*Cotton Linters.* Linters are the short, fuzzy, hairlike fibers that remain on the seeds after they have been separated from the fiber in the cotton gin. The cotton linters are removed from the seeds by a second ginning process. They serve as raw material for the manufacture of rayon, other synthetics, plastics, shatterproof glass, guncotton, photographic film, fast-drying lacquers, and for various other purposes.

*Hulls.* The hulls, which are the outside portion of the cotton seeds, are obtained after the linters have been removed. The hulls are used as fertilizer, because they are rich in nitrogen, an important plant food. They are also used in the manufacture of paper, plastics, cattle feed, and as a base for explosives.

*Inner Seeds.* The meat of the seed inside the hull yields cottonseed oil, which is used in cooking oils and compounds and in the manufacture of soap. The residue of the inner seed becomes cattle feed.

**Varieties of Cotton.** Soil and climatic conditions affect the length and the character of cotton fibers. The relative fineness of the fiber seems to vary directly with the length of staple, the shortest staple being the coarsest type. The names of countries or of sections of countries where cotton is produced usually indicate the quality and the kind of cotton; these varieties may be used as a general classification.

Cottons of high quality have been successfully transplanted; the name of the country or section in which they originated is usually retained. The better-known cottons that are of importance in the United States are described here according to their rank.

*Sea Island Cotton.* Sea Island cotton received its name from Sea Island off the coast of Georgia. This cotton is now successfully grown on other islands off the southern coast of the United States as well as along the seacoast of the mainland. As nearness to the ocean provides the moisture so necessary to the proper development of good-quality cotton, Sea Island cotton has an extremely fine, long staple, ranging from 1½ to 2½ inches in length. Wherever this variety has been successfully transplanted, it has produced the finest and the longest staple of all cotton fibers. Sea Island cotton is used for the highest-quality cotton fabrics, including laces, fine sewing thread, and imitations of silk.

*Egyptian Cotton.* As the name implies, Egyptian cotton originated in Egypt. It is now under cultivation in the states of Arizona and California. Egyptian cotton is brownish yellow, and therefore is usually bleached. Its staple is 1¼ to 1¾ inches in length, being second best to Sea Island cotton. Egyptian cotton transplanted to Arizona has reproduced an American Egyptian cotton now known as *Pima cotton,* which yields a very long staple, from 1⅜ to 1⅝ inches in length.

Egyptian and American Egyptian cotton are used in making the finest cotton goods today.

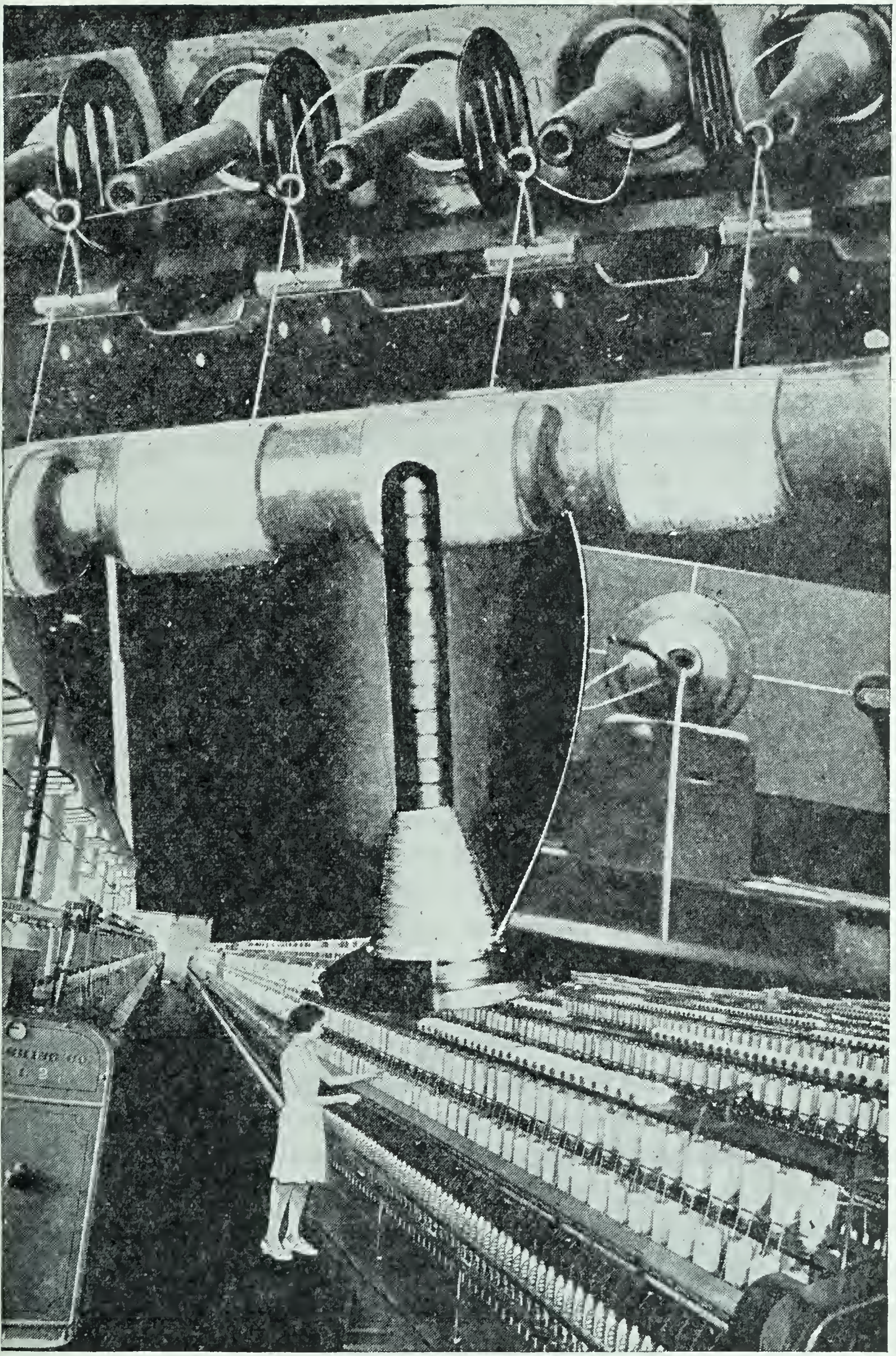
*American Upland Cotton.* American Upland cotton supplies the bulk of the United States crop and is used for most cotton products. American Upland cotton yields a soft, fairly strong fiber. Its staple is ¾ inch to 1⅛ inches in length.

Another American brand of cotton that is valued because of its long staple, from 1⅛ to 1¼ inches in length, is *Peeler cotton,* first grown in the Mississippi Delta. As used today, the name refers to cotton grown in any of the low, wet portions of the southern states.

American Upland cotton is used in popular-priced cotton fabrics.

*Peruvian Cotton.* Peruvian cotton is harsh and wiry; its staple is from 1 to 1¼ inches in length. Its rough quality makes it resemble wool, and it is sometimes mixed with wool for the purpose of adulteration. Peru also produces cotton of finer quality.

*Asiatic Cotton.* Cotton grown in India, China, Asia Minor, Iran, Indo-China, and Japan is called Asiatic cotton. It is of relatively short



The lower part of this picture shows a complete view of a ring spinning frame. A series of bobbins is shown in the upper part of the picture, and an enlarged view of a single bobbin appears in the center.

staple, nearly all being less than 1 inch in length. Its use is therefore limited to low-grade cotton goods.

**Manufacturing Processes of Cotton.** Because cotton is such a universal fiber, its manufacture into yarn was used in Chapter III to illustrate the spinning process.

Cotton fabrics may be produced in any weave. In the finishing processes, cotton cloth may be given:

Full bleaching—for clear whiteness.
Mercerizing—for strength, luster, and affinity for dyes.
Singeing—for smoothness.
Sizing—for stiffness, smoothness, and body.
Weighting—for bulk.
Preshrinking—for serviceability.
Sanforizing—for maximum preshrinking.
Calendering—for luster.
Schreinerizing—for luster.
Beetling—for flattened effects.
Napping—for softness, warmth, and absorbency.
Crepe effects—for crease resistance.

The types of dyes used for cotton and their degree of fastness to light and to washing were explained in Chapter VI.

*Simulating Linen.* Cotton yarn can be spun to simulate the irregularities characteristic of linen fiber. The cloth is sized, beetled, and calendered similarly to linen and is then woven in the damask and other patterns usually associated with linen fabrics.

*Simulating Wool.* Cotton fibers can be treated with chemicals to give them the roughness characteristic of wool fibers. The fibers are spun into thick yarns to increase the similarity. The finished cloth is napped or roughened to produce a wool-like surface. As Peruvian cotton fiber has an inherent similarity to wool fiber, it is sometimes mixed with American Upland cotton to simulate wool.

*Simulating Silk.* The highest quality of cotton fiber, when spun to a high yarn count and then mercerized, simulates silk. The use of the satin weave in spinning produces a silklike luster. The cotton fabric may be singed and calendered to smooth its surface and to increase the luster. Cotton fabrics are frequently schreinerized to obtain an added lustrous effect.

**Judging Cotton Fabrics.** In recent years manufacturers have increasingly placed labels on finished consumers' goods to indicate the cloth count; the fiber content; the shrinkage to be expected; permanency of crispness (if any); fastness of dye to strong light, washing, and dry cleaning; and general instructions on the maintenance and care of a fabric.

Such labels protect the consumer by the implication that the finished goods will give wear commensurate with the information that appears on the label. The labels also protect the manufacturer from the consumer's possible misunderstanding of the quality and durability of a fabric and from complaint if the fabric is improperly handled when washed or dry-cleaned.

It should be of interest to the reader to observe how the information gained in the first chapters of this book concerning the essential qualities of the fibers, their spinning into yarn and weaving into cloth, can now be applied to the actual purchase of consumers' goods. Proper evaluation is based on the following summarization.

*Strength.* Compact construction, represented by high cloth count, helps a fabric keep its shape and give longer wear. Strength is also judged by the character of the cotton yarns, which should be of long staple and tightly twisted. A sample of the fabric may be tested for strength by holding it in both hands and pressing down firmly with the thumbs while pulling. If the cloth gives easily, it will not stand the strain of wear.

*Amount of Sizing.* If a cotton fabric is oversized, rubbing or tearing a sample swatch will cause shedding of excess starch. Holding the fabric to the light will reveal defects in construction that may have been concealed by sizing. Washing a sample will remove excess sizing, showing sleazy construction. An absolute test for starch is made by dipping a sample in a very dilute iodine solution; a dark-blue color indicates starch.

*Crease Resistance.* The tendency of cotton fabrics to wrinkle easily may be offset by finishing processes that give a crease-resistant quality.

*Heat Conductivity.* Cotton fabrics make excellent summer clothing because cotton is a good conductor of heat. Crisp, clean, fine cotton fabrics look cool as well as feel cool. Napped or pile-weave cotton fabric has a warmth-giving quality.

*Absorbency.* Cotton is not a naturally absorbent fiber, but certain finishing processes, such as mercerizing and napping, increase absorbency of cotton fabric.

*Cleanliness and Washability.* Although cotton attracts dirt particles because of its roughness, this disadvantage is offset by the washability of the fiber. Cotton fabrics are not injured even in strong, hot solutions of alkalies; therefore, they can stand laundering with strong soap. They withstand rough handling and considerable heat in ironing. Because of low resistance to acids, cotton deteriorates when exposed to perspiration. Mercerizing and new types of finishes, however, in many cases offset this.

*Shrinkage.* A great amount of shrinkage will occur if cotton fabric is loosely woven and stiffened with starch, which is usually lost in washing. Preshrinking finishing processes minimize shrinkage in cotton fabrics.

*Fastness of Color.* Fastness of dye to washing can be tested by washing a sample in hot water. Fastness to light can be tested by exposing a sample to light for a week or more. Penetration or thoroughness of dye can be tested by raveling a yarn and examining its unexposed surfaces.

*Resistance to Mildew and Moths.* Cotton fabrics, especially sized fabrics, mildew readily when permitted to remain in a damp condition. New processes, in many cases, offset this tendency to mildew. Cotton is never attacked by moths.

**Construction of Sheets.** As sheets are an important item in the budget of the American family, the Government ruling that controls the labeling of sheets is explained here. It affords an excellent example of consumer guidance.

*Cloth Count.* Sheets are labeled as belonging to one of four types: 112, 128, 140, 180. The figures are obtained by adding the number of warp and filling yarns to the square inch, which represents the cloth count. The higher the count, the more close and uniform the weave; the more compact the weave, the greater the resistance to wear.

Types 112, 128, and 140 are known as *muslin.* Muslin is made from cotton yarns that have been carded but not combed. Of the three muslin types, 140 represents the best quality, because such sheets are made from good-quality carded cotton yarns that are coarser and

UNITED STATES GOVERNMENT MINIMUM SPECIFICATIONS FOR SHEETING

| Specifications | Type 112 | Type 128 | Type 140 | Type 180 |
|---|---|---|---|---|
| Cloth count per square inch | 56 × 56 | 68 × 60 | 74 × 66 | 96 × 84 |
| Weight by ounces per square yard | 3.7 | 4.0 | 4.6 | 3.9 |
| Tensile strength, in pounds: | | | | |
| Warp | 50 | 60 | 70 | 60 |
| Filling | 45 | 50 | 70 | 60 |
| Number of stitches per inch | 14 | 14 | 14 | 14 |
| Added sizing | 8.5% | 5% | 2% | 1% |
| Selvage | Tape | Tape | Tape | Tape |

heavier and more compactly constructed than types 112 and 128. As heavier yarn gives greater durability, the Government preference is for type 140. Heavy muslin sheets are practical and economical because they are moderately priced and withstand wear longest, particularly when subjected to hard laundering.

Type 180 represents the sheets that are known as *percale.* Percale is woven from fine-quality, long-staple cotton yarns that have been combed as well as carded and also have been given a tighter twist. The cloth count is high because of the fineness of the yarns and their compact construction. Such yarns make lightweight sheets of fine texture; they are desirable for summer use. There is a gain in luxury but a slight sacrifice in durability because, all other conditions being equal, the heavier fabric gives the longest wear.

*Weight.* Many weights of sheets are available, varying from 3¼ to 5¼ ounces per square yard. But good weight should be the result of compact construction, not of excessive starch sizing. Therefore, it is advisable for the consumer to test sheets for sizing.

*Length and Width.* Sheets should always be long enough and wide enough to tuck underneath a mattress at least 6 inches on all sides.

The better grades of sheets are torn to size to make certain that the length is absolutely even; therefore, the size is given as a torn size; that is, before hemming. After hemming, sheets are 5 inches shorter; after washing, there is another decrease in length of approximately 5 inches, or 5 per cent, due to shrinkage.

Sheets 108 inches long should be selected. As about 10 inches must be deducted from the stated torn size for hems and shrinkage allowance, 98 inches remain for use. The average mattress is 74 inches long and 6 inches thick; thus, 6 inches will be left for tucking under when a sheet is used to cover the mattress directly. Also when a sheet is used as an upper sheet, there will be a sufficiently wide turnover to protect blankets.

Careful consideration should be given also to the width of sheets. For a double bed, a sheet should be 81 to 90 inches wide. A three-quarter bed requires a sheet 72 inches wide; and a single bed, a width of 63 to 72 inches.

## Glossary of Cotton Fabrics[1]

**Airplane fabric.** Plain weave. Closely woven, desized, durable medium-weight and lightweight fabric used in the manufacture of airplane wings and parts. Made of combed and mercerized yarns; usually in square weave. Many fabrics go under this name. Most important is fancy, irregular broken weave.

**Armure.** Drapery fabric with a small woven design, usually on a rep foundation. Can be either Jacquard or dobby weave. Pattern is made by floating warp threads over the surface, giving a raised effect.

**Backing or back cloth.** Gray goods, usually print cloth, used to take up surplus dye and to reinforce fabric on the printing machine.

**Balloon cloth.** Plain weave. Of finest Pima yarns. High thread count. The extremely fine yarns give the fabric luster. Usually mercerized. When used for balloons, given a special coating. Also used for frocks, shirts, typewriter ribbons.

**Batiste.** Plain weave. A sheer, soft-finished fabric of the lawn family. Comes in various grades from coarse to very fine. Generally woven of combed yarns, but occasionally of carded. Often given high mercerization, bleached, dyed, or printed. Sometimes embroidered.

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[1] Specially prepared by The Cotton Textile Institute, Inc.

**Beach cloth.** A strong, coarse fabric of plain weave, heavy yarns, and low thread count. Has the appearance of crash. There are a number of versions of this fabric.

**Bedford cord.** A carded yarn, wale, or cord material. Two-ply warp yarns and heavier single or ply yarns used as a backing. These heavy yarns are caught at intervals in the weaving of the cloth. Single yarns sometimes used in cheaper versions; the effect of the cord is obtained in the weaving. Wale runs in warp. Can be napped in back, bleached, dyed, or printed. Often the face of the cloth is given a suede finish.

**Bengaline.** Rib effect with a high luster. Has somewhat the appearance of grosgrain ribbon. For draperies and frocks.

**Bird's-eye (diaper cloth).** Fabric woven on a dobby loom of carded yarns in tiny geometric designs that look like the eye of a bird, or in diamond effect. Heavier filling yarns are loosely twisted, making the cloth absorbent.

**Blanket cloth.** Plain or twill weave, 60 × 80 inches and over. Coarse, soft filled yarns, filling heavily napped both sides. Generally bleached, yarn dyed in plaids or stripes, or with colored filling edge.

**Book cloth.** Coarse, plain-weave print cloth or sheeting. Dyed, heavily sized, often pyroxylin coated, or embossed.

**Box loom.** Fabrics made with right-hand and left-hand twist in filling, notably box-loom crepe. Such fabrics as ginghams and plaids are also made on box looms.

**Broadcloth.** Plain, closely woven fabrics of either carded or combed yarns with a rib effect. Originally a poplin or adapted from poplin construction, broadcloths are of lighter weight with a finer rib. Ribs are made by using medium warp yarn and finer filling. Many more warp threads than filling. Better broadcloths are combed ply yarns and high thread counts. Coarser fabrics often have both ply and single carded yarns.

**Brocade.** Basic weave is satin. Elaborate lustrous design woven on a Jacquard loom. Has a raised appearance, usually on a sateen ground but often on twill or rep. The design is on the surface only. Multicolored yarns used.

**Brocatelle.** A heavier version of brocade. Woven on a Jacquard loom with two, three, four, or more shuttles. Ordinary warp yarns but fewer twists in filling yarns. Has extra backing threads. The floating warp yarns over the backing yarns make the design stand out in relief.

**Bunting.** Plain weave, in low or medium thread count. Open weave similar to cheesecloth or scrim. Dyed or printed.

**Calico.** A low- or medium-count cotton print cloth with special designs called calico designs. Many Early American designs are still in use.

**Cambric.** Originally linen, now cotton print cloth or lightweight sheeting construction. Given special sizing and calendered finish.

**Canton flannel.** Warp-faced twill flannel with a heavy, soft filling yarn and lighter warp than filling yarn. Has a long nap on one side only. Comes unbleached or bleached. Used for men's work gloves, infants' wear, linings.

**Challis.** Plain or twill weave, printed or dyed. Given a soft finish and very slight nap.

**Chambray.** Pattern is formed by the use of colored yarn warp and natural or white filling. This gives a tiny check or mottled effect. There are endless variations of this fabric, such as stripes, satin stripes, and so on. The end-to-end chambrays are woven with alternate colored and natural or white yarns in warp and all natural or white yarns in filling or vice versa. Many novelties on the market.

**Cheesecloth (and tobacco cloths).** Loose, open, plain light weave with low thread count. Print cloth yarns. Cheesecloths range from 25 to 55 inches in width. Tobacco cloths are 36 inches and over in width with a somewhat lower thread count than cheesecloths. When bleached, starched, or permanently finished, known also as scrim. Other names, depending upon finish, are gauze, bunting.

**Chenille.** Heavy, soft filled yarn with a long pile cut completely round the yarn.

**Cheviot.** A strong twilled fabric woven with a colored stripe or check.

**Chiffon.** A sheer voile with a dull finish; of fine, hard-twisted yarns. Often dyed or printed.

**Chintz.** A print cloth or high-count fine sheeting with bright attractive floral or geometric designs, both large and small. Often given a permanent or semipermanent glaze; then known as glazed chintz. For draperies, slip covers, frocks.

**Corduroy.** A ribbed pile fabric with a high, soft luster. Made with extra filling threads or extra warp threads. In weaving, the extra filling yarns form loops or floats over the ground threads. After weaving, the loop threads are cut on a special machine. The threads are then brushed, forming a pile.

**Cottonade.** Generally three-harness, left-hand, warp-faced twill of coarse yarns. Comes mostly in dark stripes on a solid or medium-dark ground. Durable finish.

**Coutil.** A strong three-harness herringbone or reverse-twist twill weave of high count. For suits, corsets, and other purposes in which a durable fabric is required.

**Covert.** A medium-weight or medium-lightweight fabric with warp-faced left-hand twill. Usually of two-ply warp yarns and single or two-ply filling. Mixed yarns, such as natural and color in warp and matching color alone in filling. Has a mottled appearance. Often made with mock-twisted single yarns consisting of two rovings, one white and one color in warp and all color in filling.

**Crash.** Name given to fabrics having coarse, uneven yarns in both plain and twill weaves. Usually sheeting, osnaburg, or twill-weave constructions with a special finish. Used for toweling and drapery purposes. In lighter weights used for suits and dresses.

**Crepe.** Has a pebbly or crinkled surface produced by use of special crepe yarns. Can be either crepe, granite, or plain weave. Generally, mixed-twist crepe yarns used in both warp and filling, but occasionally crepe yarns used only in the warp or the filling. Mostly woven on a box loom.

**Cretonne.** Generally, a medium or heavy sheeting or osnaburg printed in bold, bright designs. Used for draperies and other household articles.

**Crinoline.** Cheesecloth, tobacco cloth, or loosely woven sheetings given a stiff starched or plastic finish. Gives a firm appearance and feel.

**Damask.** Design, woven on Jacquard loom, on both sides of the fabric. Usually given a lustrous, smooth finish when used for tablecloths and a soft or lustrous finish for draperies or upholstery.

**Denim.** A durable fabric of the twill family. Usually of single hard-twisted yarns with colored warp and natural or white filling.

**Dimity.** A sheer white, dyed, or printed fabric of plain weave with a spaced rib made with warp cords. This rib may be single, double, or in groups. Comes also in checks and other novelty versions. Coarser small-check dimities are known as pajama checks.

**Dobby.** Woven on a dobby loom. All material with small figures, such as dots and geometric designs; floral patterns woven in the fabric, such as certain shirtings, huck towels, diaper cloth, certain dress goods, drapery and upholstery fabrics. Can be dyed, bleached, or yarn-dyed in many colors.

**Domet flannel.** See also "Outing flannel." Plain or twill weave. Generally white with a longer nap than outing flannel, although the names are interchangeable. Soft filled yarns of medium or light weight.

**Dotted swiss.** Generally a voile or lawn construction woven with either clip spots or swivel dots. The clip spot is the more popular version. The fabric is given a crisp, clear finish, which may be permanent or semipermanent. Often yarn-dyed dots are woven on a white ground, or a dark ground has white dots. Many imitations on the market, pigment dots, wool dots, and others.

**Drill.** A durable fabric of medium weight. Usually, three-harness warp-faced twills made of carded sheeting yarns. Comes in various weights and thread counts. When dyed, known as khaki, tickings, silesia, herringbones. One thread goes over two filling yarns; then under.

**Druid's cloth.** See "Monk's cloth."

**Duck.** The name duck covers a wide range of fabrics. It is the most durable fabric made. A closely woven, heavy material. The most important fabrics in this group are known as number duck, army duck, and flat or ounce duck. Number and army ducks are always of plain weave with medium or heavy ply yarns; army ducks are the lighter. Ounce ducks always have single warp yarns woven in pairs and single or ply filling yarns. Other names for variations of these fabrics are sail duck, belt duck, hose duck, tire duck (such as breaker, cord, chafer), wide and narrow duck, biscuit duck, harvester duck, oil press duck, wagon duck, enameling duck, boot duck, canvas, and so on. Generally of ply yarns in warp and yarns of various sizes and weights in filling.

**Duvetyn.** See "Suede cloth."

**Eponge.** See "Ratiné."

**Express stripe.** Warp-faced twill with a woven stripe. A durable fabric. An even number of unbleached and blue yarns are used in the pattern, forming a stripe.

**Friezette.** An uncut loop or pile ribbed fabric similar to a heavy rib or rep. Of heavy yarns, usually mixed in color.

**Gabardine.** A distinctive steep-diagonal warp-faced twill of carded or combed yarns. Twill is to the left if made with all single yarns, and to the right when ply warp and single filling are used.

**Gauze.** See "Cheesecloth." Usually bleached; often specially treated, as when used for bandages. Better cheesecloths are also used for less expensive infants' items under trade names.

**Gingham.** Plain-weave, medium-weight or lightweight fabrics. Can be either combed or carded yarns. Usually woven on a box loom. Colored and white yarns or multicolored yarns form the pattern. Same number and variation of yarns in the warp as in the filling, forming squares, plaids, and similar patterns. Strange to say, a solid-color gingham is called a novelty gingham. Endless variations in color and design. Tissue ginghams are sheer ginghams made with lighter-weight yarns.

**Glazed chintz.** Generally a print cloth or percale or a lightweight sheeting having bright, attractive floral or geometric designs. The fabric has a semipermanent or permanent glaze finish. Sometimes calendered or given a plastic finish. Fine twills are also used for this purpose.

**Granite.** See "Mummy cloth."

**Grosgrain.** Plain-weave fabric similar to poplin but with a heavier rib effect and coarser, lower thread count. Made with single or with ply filling.

**Hickory cloth.** Resembles ticking somewhat, but of lighter weight and not so firm a weave.

**Holland.** Usually a low-count print cloth or high-count cheesecloth, heavily sized and glazed. Occasionally, sheeting constructions are used.

**Hopsacking.** Made of yarns about the same weight as osnaburg in a loose and low thread count. Sometimes made with spiral yarns. It has a soft texture and is of the homespun family of cottons. Sometimes made with fine warp and heavier filling. Many versions of this fabric.

**Huck.** Small-figured dobby weave used for towels. Has a rough surface. Comes bleached or with yarn-dyed striped border.

**Jaspé.** A durable, narrow woven stripe done on a dobby loom with multicolored threads or with different shades of the same color. Has a shadow effect. Sometimes printed versions are shown in the market. Often small dots are woven into the fabric. Used for draperies and slip covers.

**Jeans.** Three-harness warp-faced twills of lightweight sheeting yarns. One warp thread goes over two or more filling threads, then under, moving one pick higher for each return filling thread. Sometimes made in chevron or herringbone versions.

**Kasha cloth.** Flannel with napped face and mottled color. Usually tan or brown. An unbleached soft filled sheeting. Mixed yarns are used with sized warp yarns that take dye and filling yarns with natural wax that do not take dye. When bale-dyed, the result is a mottled appearance.

**Khaki.** See "Twill."

**Lawn.** Sheer and medium-sheer plain-weave fabrics made with lightweight yarns and medium to high count. Can be bleached, dyed, or printed. When finished, it is also known by the name of such special finishes as batiste, organdy.

**Longcloth.** Also known as fineplain. A plain-weave, closely woven, high-count, fine-quality fabric. The weight is between a print cloth and lawn. Generally combed finer yarns, and with more threads to the square inch than percales. A few are made of print-cloth yarns.

**Madras.** Usually woven in stripes, cords, dobby, and Jacquard. Mostly all white, but in a number of cases done with a patterned warp and white filling, such as white and color warp, or color-and-color warp and white filling, or vice versa. Often a stripe is woven in solid colors. A number of variations of the above.

**Marquisette.** Lightweight open-mesh fabric of low thread count. Can be either a gauze or leno weave. Made with ply or single yarns. Dots and figures can be woven in. Either combed or carded. Generally the ply yarns are combed. Can be bleached, dyed, or printed.

**Matelassé.** Woven on a box loom. A real matelassé is a double warp-faced fabric, stitched together in warp and filling. Face of cloth has a fine warp and filling, the back a fine warp and heavy filling. Other matelassé crepes are made by interlacing crepe yarns with ordinary yarns in warp and filling, or in filling only. Comes in dobby or Jacquard designs. Has a slightly quilted appearance.

**Moleskin.** Mostly a right-hand filling-faced twill with a soft, smooth, shiny face. High thread count, usually many more fine filling threads and fewer heavier warp threads. Generally a napped back.

**Monk's cloth.** Basket weave, a variation of the plain weave. Made with heavy rough yarns. Can be a 1 × 1, 2 × 2, 4 × 4, or 8 × 8 thread; the best known is the 4 × 4. These four threads in warp and filling are placed flat together and woven over and under in a plain weave; the resulting appearance is that of a basket.

**Mummy cloth.** Sometimes called granite cloth; also momie cloth. Although this fabric has the appearance of crepe with a crinkled surface, it is not made with crepe yarns but with ordinary yarns and is woven on a dobby loom. Can be bleached, dyed, or printed.

**Muslin.** Coarse type of cotton fabric made of carded yarns; of various thread counts up to 140. Gray print cloths and lightweight sheetings known as unbleached muslins.

**Nainsook.** Plain weave. Mostly fine combed-yarn lawns, given a soft finish and light luster. Comes bleached and sometimes dyed.

**Netting.** A lightweight or heavy open-weave, knotted fabric. The knots come at each corner of the square. Ranges in weight from very sheer to very heavy fabrics, from fine nets to fishing or laundry nets.

**Oilcloth.** Sheetings or print cloths that are printed, bleached, or dyed, and given a special linseed oil and pigment preparation.

**Organdy.** Plain weave. A sheer transparent lawn of lightweight yarns. Slightly lower construction than ordinary lawns. The filling is slightly finer than the warp yarns. Fewer filling than warp threads. Comes in many variations, such as permanent crinkles, leno effects, embroidery, plain or crinkled mixtures, clip spots. Bleached, dyed, or printed. Given a stiff finish, either starched or a permanent stiff, starchless finish.

**Osnaburg.** A plain weave made of low-grade cotton, medium and heavy coarse yarns. Low thread count. When made of waste mixed with low-grade cotton, it is known as part-waste osnaburg; when of short-staple, low-grade white cotton, known as clean osnaburg. Woven with colored stripe and check effects, known as crash toweling. Comes in both wide and narrow widths and in innumerable variations in weight and thread count. Known also under the names of drapery crash, linene, hopsacking, suiting. Has a number of uses.

**Outing flannel.** Can be either plain or twill weave. Lightweight or medium-weight soft filled single yarn with nap on both sides. Mostly yarn-dyed. Woven in stripes, plaids, or checks. Sometimes bleached or piece-dyed, and occasionally printed.

**Oxford.** A plain weave of medium and heavy weights. Made with a variety of yarns. The majority of oxfords are of combed yarns, with heavier filling than warp yarns. Cheaper grades are mixed carded and combed yarns, and sometimes all carded yarns. Two warp yarns, placed flat next to each other, are woven over and under one heavier filling thread. Usually mercerized. A number of variations of this weave are on the market. For shirtings, frocks, and similar purposes.

**Pajama check.** A lightweight or medium-weight plain-weave fabric with small-sized or medium-sized cord checks. Usually carded yarns. Of the dimity family.

**Percale.** Plain-weave medium-weight-yarn fabric in the print cloth group. Thread count, 80 × 80 and over. Usually given a firm finish. Can be bleached, dyed, or printed. Has innumerable uses.

**Percaline.** In the lightweight, low-count print cloth or lawn group with a bright, soft finish. Usually mercerized. Made in both fine and cheap versions. Used for the lining of furs.

**Piqué.** Has a warp or filling wale or cord, usually warp. Can be carded or combed yarns. It is woven on a dobby loom or with a dobby motion. A heavy stuffer yarn is used in back of the cloth; this heavy yarn is caught at intervals by a filling thread. Groups of fine warp yarns are woven on the surface over the back stuffer yarn, forming a rib. Many of the cheaper versions are woven without this stuffer yarn. Other versions of piqué are irregular or novelty wales, woven dots, bird's-eye, diamond squares, ladder effects.

**Plissé.** A plain-weave crepe or crinkled fabric that has been specially treated. The plain fabric, which can be print cloth, lawn, or lightweight sheeting, is bleached, dyed, or printed; then covered with a gum in the desired pattern—stripe, check, floral, or geometric. The fabric is then passed through a caustic soda bath. The soda crinkles or crepes the fabric, leaving the gummed sections plain. When the gum is washed off, the pattern is revealed.

**Plush.** Plain-weave fabric with occasional twill or novelty versions. A deep velvetlike pile woven on a cam loom in what is known as a velvet weave. Many plushes are made on a Jacquard loom in the form of patterns with many colored yarns. The ground yarns are generally two-ply carded. The double fabric is woven face to face and the warp yarns severed on the loom. Generally piece-dyed, and occasionally printed.

**Pongee.** Plain weave adapted from the early silk fabric of that name. Generally combed yarns. More and heavier filling yarns than warp. Schreinerized to have a silklike finish.

**Poplin.** Has a heavier rib effect than broadcloth. Heavier filling than warp yarns, and more threads in the warp than filling. Print cloth yarns mostly. Combed yarns in the better cloths. Many mixtures made. Poplin comes in many variations, such as slubs, nubs, and yarn-dyed checks and stripes. Mainly dyed solid colors or printed. Often given special finishes, such as water-repellent, fire-retardant, mildewproof.

**Print cloth.** Carded cloth made with same yarns as cheesecloth, but with more warp and filling threads to the inch. Most print cloths are made in narrow widths up to 40 inches. Given a range of finishes, thus producing cambric, muslin, lawn, longcloth, and printed percales.

**Ratiné.** A plain-weave loosely woven fabric with a rough, nubby appearance. This is obtained by the use of ratiné yarns; that is, one heavy and two fine, twisted together at different tensions, thus forming a knotty ply yarn. In less expensive versions, ordinary yarn is used in the warp with ratiné yarn in the filling. Can be bleached, dyed, or printed, and given a high luster or other finishes.

**Rep.** Plain weave. Has a rib running across the fabric. The rib stands out more than in broadcloth or poplin. Usually given a high luster, although this is not always the case. Rib produced by heavy warp ends or extra floating filling. Also formed by using two warp beams with slack and tension warp ends. Two slacks are woven as one, and the tension is woven plain.

**Sateen.** A satin weave. Usually woven so that the surface is smooth and the finish lustrous, resembling satin. Can be either a strong warp-faced sateen or a softer filling sateen. Often, though not always, filling sateens have a softer finish than warp sateens. Can be either carded or combed yarns.

**Scrim.** A durable plain weave. Generally ply yarns and low thread count. Somewhat similar to voile but a much lower thread count. Cheesecloth with a special finish is often referred to as scrim. Comes in many variations. Usually has a selvage. Generally carded, but a few combed varieties on the market.

**Seersucker.** A plain weave. Usually a medium-weight or medium heavy-weight fabric with a woven crinkled stripe, check, or plaid. Yarn-dyed or bleached, occasionally overprinted. The woven crinkle is made by alternating slack tension in warp yarns. Not to be confused with plissé.

**Shantung.** Plain weave. Has a rib effect formed by slub yarns. Certain parts of the yarn are not given the usual number of twists. These places form the slub in the rib.

**Sheetings.** Plain weave. Mostly carded but occasionally combed yarns in all weights, light, medium, and heavy. Generally about the same number of yarns in warp as in filling, but often warp yarns are heavier than filling. Sheetings come in both wide and narrow widths. Yarn sizes range from 10s to 29s.

**Silesia.** Generally a lightweight twill lining with a calendered glaze.

**Suede cloth.** Sheeting napped on one side to resemble leather suede. Duvetyn, which is similar to suede, has a longer nap.

**Tapestry.** A closely woven yarn-dyed figured material with two or more sets of warp and filling, often plied. Woven on a Jacquard loom. Comes in both fine and coarse versions. The reverse side is smooth.

**Terry cloth.** A fabric having uncut loops on both sides of the cloth. Woven on a dobby loom with terry arrangement. Various sizes and numbers of yarns are used in picks and ends, forming different versions of terry cloth. Can also be woven on a Jacquard loom to form designs. Can be yarn-dyed in different colors to form patterns. Bleached, piece-dyed, and even printed.

**Tickings.** A variety of fabrics are known by this name. The main weave is a closely woven, strong yarn twill. Spaced colored and natural or white yarns repeated in the warp, and all natural or white in the filling, forming a stripe. Several color combinations used, such as blue and white, brown and white, red and white. Heavy warp sateens as well as heavy sheetings are printed and sold as tickings. Jacquard damask tickings woven in lovely damask effects also sold for this purpose, as well as other fabrics, such as drills.

**Tobacco cloth.** See "Cheesecloth."

**Twill.** Cotton fabric in twill weave. May be right-hand or left-hand twills. Known as drills, jeans, gabardines, denims, serge, canton flannel, cottonade, tickings, and others, depending on the finish and thread count.

**Typewriter ribbon cloth.** Fine fabric of plain weave. Often balloon cloth. Made with finest regular yarns, then cut into strips, and specially finished.

**Velveteen.** Twill or plain weave with a short, glowing, lustrous pile. Ply or single yarns are used, which can be either combed or carded. Many more filling yarns than warp. The extra soft-twisted filling threads that float over the surface of the cloth are cut, forming the pile. Thickness of pile depends on the number of threads used. Can be dyed or printed.

**Venetian.** A durable warp-faced eight-harness sateen of fine reverse-twist yarns.

**Voile.** A soft yet firm sheer fabric of plain weave. Generally made of combed hard-twisted single yarns, although ply yarns are also used. About the same number of yarns in warp as in filling. Occasionally dots are woven in and a crisp finish given the fabric; then it is sold as swiss.

**Whipcord.** A serviceable fabric with a prominent steep twill effect. Often mercerized and preshrunk. Generally a left-hand warp twill. Many are finished with a slight nap at the back of the cloth. While some are woven in solid colors, others have mixed warp and solid matching color filling.

**Wigan.** Usually made of print cloth or lightweight sheetings. Dyed in dark colors and starched and calendered. Used mostly for interlinings.

*Test yourself on this chapter by answering these questions:*

1. What are the by-products of the cotton plant? For what are they used?

2. How would you judge cotton fabrics?

3. Name the more important varieties of cotton grown in the United States, according to their quality.

4. What climate is necessary for the growth of cotton?

5. Which country produces coarse, wiry cotton?

6. What proportion of the world's supply of cotton is produced in the United States?

7. How can cotton be made to simulate linen? Wool? Silk?

8. What is the difference between muslin and percale?

9. How are sheets labeled? What is the basis for labeling?

10. How may the strength of a fabric be determined? The amount of sizing?

11. Why are long fibers separated from short fibers? How may the consumer identify finished goods made from long staple?

12. Name some of the finishing processes.

13. What is ginning? What are linters? Hulls?

14. Why is the more expensive method of vat dyeing used for such an inexpensive fiber as cotton?

15. Why are cotton lisle hose preferred by men?

## Suggested Readings

Cotton Textile Institute, *Cotton, from Raw Material to Finished Product.*
Crawford, M. D. C., *The Heritage of Cotton.*
Darby, W. D., *Cotton, The Universal Fiber.*
Denny, G. G., *Fabrics and How to Know Them.*
Dickson, H., *The Story of King Cotton.*
Dooley, W. H., *Textiles,* Chapters 12, 14.
Dyer, E., *Textile Fabrics,* Chapter 7.
Haven, G. B., *Industrial Fabrics.*
Hess, K. P., *Textile Fibers and Their Use,* Chapter 4, Section 2.
Matthews, J. M., *The Textile Fibers,* Chapters 12, 13, 14.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 4.
Nichols, H. W., and Broomhead, W. H., *Standard Cotton Cloths and Their Construction.*
Nystrom, P. H., *Textiles,* Chapters 4, 6, 7.
Small, C. P., *How to Know Textiles,* Chapter 12.
Wingate, I. B., *Textile Fabrics,* Chapter 4.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 6.

# CHAPTER IX

# LINEN: COOL AND ENDURING

The fiber obtained from the stem of the flax plant was probably the first textile fiber to be used by mankind. Historical records show that linen cloth was produced and used far back in antiquity, the earliest record being the use of flax for fish nets by the neolithic lake dwellers of the Stone Age some ten thousand years ago. The Bible contains references to the use of linen.

The bodies of early Egyptian kings and nobles were swathed in yards of delicate linen, indicating that the art of spinning and weaving had reached a high state of perfection in that country six thousand years ago. Such linen burial wrappings have been found to be in good condition, proving the amazing durability of the flax fiber.

Linen has always been considered the fabric of luxury. In some ancient countries, linen was used only for ceremonial purposes, as the symbol of purity. This symbolism is readily understood by recalling the fact that the descriptive phrase "pure linen" is customarily used to describe all-linen fabrics. This symbolism is apparent when it is realized that linen always looks cool, crisp, and clean—it imparts an attractive and immaculate appearance to the persons and objects it adorns.

In some countries, certain grades of linen are more readily available and are less expensive than cotton, which is generally considered the most economical fabric. But in the United States, fine-quality linens still retain the reputation of luxuriousness and expensiveness because the finest linens are imported into this country. The flax plant must be grown in countries where there is plenty of cheap labor as well as natural facilities for extracting the fiber. Even the manufacture of the fiber into cloth requires unusual care throughout each process in order to retain the strength and beauty of the fiber.

The seed of the flax plant is valuable as the source of linseed oil, which is used in the manufacture of paints, varnishes, linoleum, oilcloth, patent leather, and oiled silk. In order to obtain the seed, flax must be allowed to overripen. As overripening destroys the value of flax as a textile fiber, the method of raising the plant is influenced by the purpose for which it is required.

**Flax-producing Countries.** The countries that produce flax of various grades are Russia, Belgium, Ireland, Poland, Scotland, France, Germany, Czechoslovakia, Austria, The Netherlands, Australia, and New Zealand. Flax is grown in Canada and in the United States (Michigan, Minnesota, and Oregon), but chiefly for its seed.

The world production of flax fiber is about 1,800,000,000 pounds a year. Statistics for the last normal year, 1938, follow.

| | *Pounds* | | *Pounds* |
|---|---|---|---|
| Russia | 1,200,000,000 | France | 52,000,000 |
| Poland | 87,000,000 | Latvia | 47,000,000 |
| Belgium | 78,000,000 | The Netherlands | 42,000,000 |
| Germany | 66,000,000 | Czechoslovakia | 26,000,000 |
| Lithuania | 57,000,000 | | |

**Qualities and Grades of Flax.** Courtrai flax, which comes from the Lys district in Belgium, produces the finest and strongest yarns. The water of the Lys River in Belgium and of the Scheldt River in The Netherlands is free from minerals and has proved especially desirable for decomposing the woody tissues of the plant, a necessary step in treating the linen fiber.

Belgium has a reputation for producing the best quality of linen, but Ireland is noted for the best workmanship. Irish linen is also prized for its fine white color and strength. The flax is spun while it is wet and the cloth is grass bleached, two processes reserved for good-quality linen.

Scotch linen is lighter in color than Irish linen. It is used extensively in making heavy-grade fabrics, such as twine and canvases for tarpaulins.

French linen ranks high. It is characterized by fine designs and the use of round yarns, as the cloth is not put through the beetling process.

Russia produces the largest quantity of the world's supply of flax. Russian flax is used for medium and coarse yarns, which are dark gray in color. Russian linen sometimes cracks because the fiber is not so carefully processed as in the countries that have a reputation for fine-linen production.

German linen is generally of medium grade.

**Cultivation of Flax.** The flax plant requires deep, rich, well-plowed soil and a cool, damp climate. Premature warm weather affects the growth and the quality of the fiber. Level land with a plentiful supply of soft, fresh water is essential. As the soil in which flax is grown must be enriched for six years before it will yield a good harvest, only one crop in seven years can be raised on a specified portion of land. Therefore, the crops must be carefully rotated. In recent years, shorter periods of rotation have been tried with success.

The flax seeds are sown by hand in April or May. When the plants are a few inches high, the weeds must be pulled by hand with extreme care to avoid injury to the delicate sprouts. In three months, the plants become straight, slender stalks from 2 to 4 feet in height, with tapering leaves and small blue or white flowers. The plant with the blue flower yields the finer fiber. The white-flowered plant produces a coarse but strong fiber.

*Harvesting.* By the end of August, the flax turns a brownish color, which indicates that the plant is about to mature; it is ready for harvesting. There must be no delay at this stage; otherwise the fiber will lose its prized luster and soft texture. The plants are pulled by hand. If the stalk is cut, the sap is lost; this loss affects the quality of the fiber. The stalk must be kept intact and the tapered ends of the fiber must be preserved, so that a smooth cloth may be spun. The stalks are tied in bundles, called beets, in preparation for extraction of the fiber.

**Preparation of the Fiber.** The seeds and the leaves are removed from the stems of the flax plant by passing the stalks through coarse combs. This process is called *rippling.*

The bundles of plants are then steeped in water. The plants are weighted down with heavy stones to insure complete immersion. This allows the tissue or woody bark surrounding the hairlike flax fiber to decompose, thus loosening the gum that binds the fiber to the stem. This decomposing or fermentation is called *retting.*

*Dew retting* is the method used in Russia. The flax straw is spread on grass and is exposed to the atmosphere for three or four weeks. This method produces strong flax, dark gray in color.

*Pool, or dam, retting* is done in Ireland. It requires less time than dew retting, from ten to fifteen days. As stagnant pools of water are used, this method sometimes causes overretting, which is responsible for brittle and weak flax fibers. Pool retting darkens the flax, giving it a bluish-gray color.

*Above:* Steeping flax in Ireland.

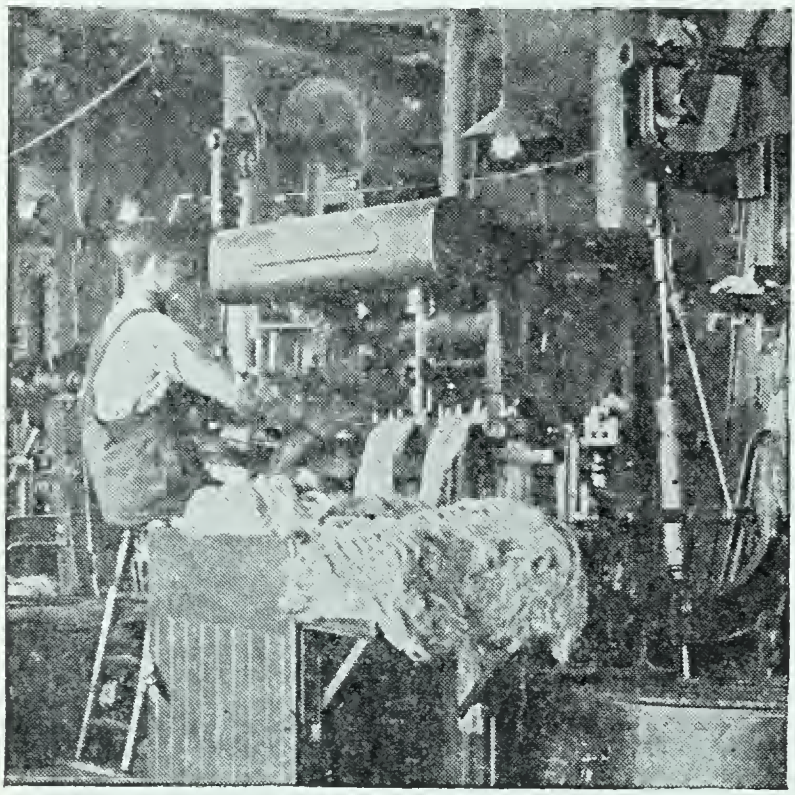
*Right:* Spreading flax to dry after retting.

*Stream retting* produces the best quality of flax fiber, as the process of fermentation can be retarded and easily controlled. The flax straw is placed in streams of cool, soft running water for five to fifteen days. This method produces superior strong linen of a pale-yellow color.

*Chemical retting* can shorten the retting process, but chemicals affect the strength and color of the flax fiber. The use of soda ash, oxalic soda, and caustic soda in warm water, or boiling in a dilute sulphuric acid solution, are the chemical methods used.

*Mechanical retting* also shortens the retting process, but the subsequent fabric is susceptible to mildew and mold.

Retting only loosens the woody bark. If flax is not retted enough, the removal of the stalk without injury to the delicate fiber is difficult. If flax is overretted, the fiber is weakened. The retting operation, as well as all other processes for producing linen fabric, therefore, requires great care.



For fine linens, hackling is done by hand.

The stalk becomes partially separated from the fiber when the wet plants are laid in the fields to dry. When the disintegrated woody tissue is dry, it is crushed by being passed through fluted iron rollers. This breaking operation reduces the stalk to small pieces of bark called *shives*.

*Scutching*. The scutching machine removes the broken shives by means of rotating wooden paddles, thus finally releasing the flax fiber from the stalk. This operation can be done by hand as well as by machinery.

*Hackling*. The simple combing process known as hackling straightens the flax fibers, separates the short from the long staple, and leaves the longer fibers in parallel formation. For very fine linen, hackling is usually done by hand and is repeated, a finer comb being used with each hackling treatment. Coarse linen is hackled by machine.

**Classification of Flax Fibers.** The short-staple flax fibers, called *tow,* are used for the spinning of irregular linen yarns. Tow is put through a carding operation, similar to the carding of cotton staple, which straightens the fibers and forms them into a sliver ready for spinning into yarn.

The long-staple fibers are used for fine linens. These are called *line,* sometimes *dressed flax.* Line fibers are from 10 to 20 inches in length. They are put through machines, called spreaders, which combine fibers of the same length, laying them parallel so that the ends overlap. The sliver thus formed passes through sets of rollers, making a rove for the final spinning process, which inserts the necessary twist.

**Spinning Flax Fiber into Yarn.** Although flax is one of the strongest fibers, it is inelastic and requires carefully controlled warm, moist atmosphere for the spinning operations. Two methods are used: dry spinning and wet spinning.

*Dry spinning* does not use moisture. It produces rough, uneven yarns, which are not especially strong. These yarns are used for making coarse, heavy, and inexpensive linen fabrics.

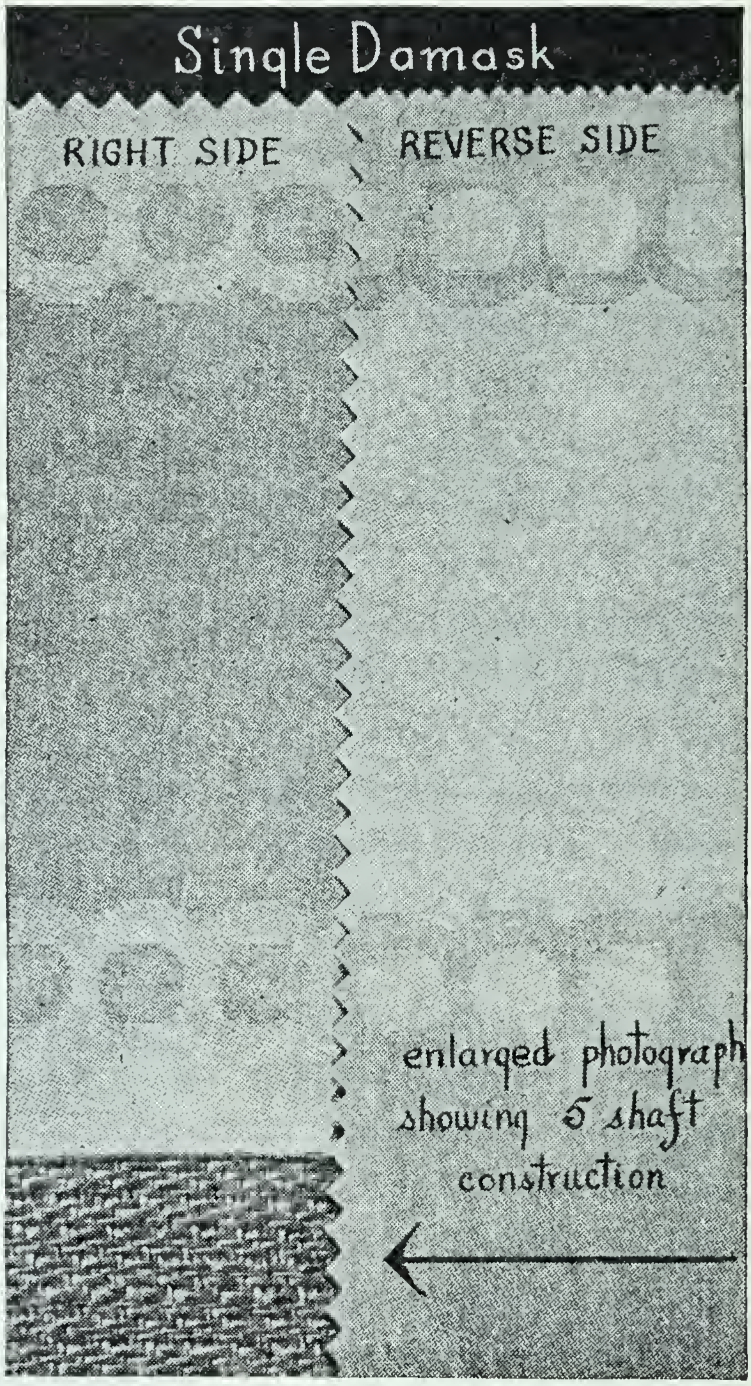
*Wet spinning* produces finer yarns. By passing the roving through hot water, the gummy substance on the fiber is dissolved, permitting drawing out of the roving into a fine yarn of high yarn count. Wet spinning requires a temperature of 120 degrees Fahrenheit, which is conducive to the production of soft, fine, even yarns.

**Linen Yarn Count.** The standard measure of flax yarn is the *cut.* If 1 pound of flax fiber is drawn out to make 300 yards, the yarn is known as No. 1s. When drawn out to make twice 300 yards, it is labeled No. 2s. The higher the yarn count, the finer the yarn. Exceptionally fine linen yarns for fine laces have been spun as high as 600s.

**Weaving Linen Yarns.** The inelasticity of the flax fiber presents a problem also in the weaving process because the fiber breaks easily under strain. A dressing is applied to the warp yarns by passing them over rotating brushes. This dressing helps linen yarns to withstand the strain of being lifted by the heddles during weaving. A very moist atmosphere is also required.

Linen fabrics usually have a balanced or squared construction, with the exception of double damask and certain sheer linens. The cloth, or thread, count is therefore always expressed as one number.

With the exception of some toweling, linen is seldom made in the pile weave. The pile weave increases absorbency, and this quality is already possessed to a large degree by any linen fabric. The twill weave is seldom used, as the fiber possesses natural strength; for the same reason, ply yarns are not necessary. The plain, satin, and Jacquard weaves are predominant. The twill weave, however, is used for linen drills in the South American market.



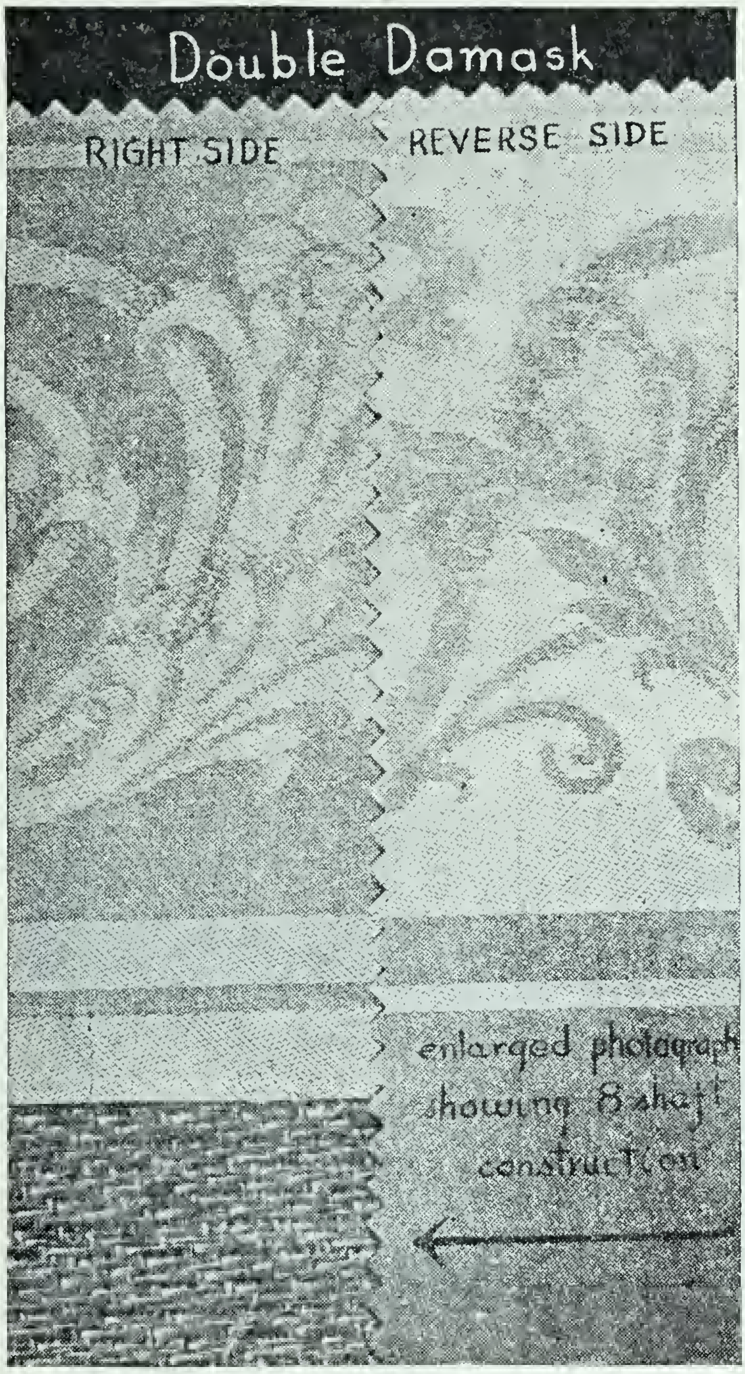
The construction and appearance of single damask is shown here for comparison with double damask on the opposite page.

*Table Linens.* Fine table linens are always woven with the Jacquard construction; there are two kinds of construction, depending on the weave. The designs in damask result from the manner in which the warp yarns pass over the filling yarns. The background is always the same on both sides.

A five-shaft satin construction on the Jacquard loom is used for *single-damask linen.* Most single damasks have the same number of warp and filling yarns, and the cloth count ranges from 100 to 200 to the square inch. Some single damasks may be overwefted about 10 to 15 per cent, but the cheaper qualities are usually underwefted; that is, some skimping is done with respect to the equalization of filling and warp.

The weave used for *double-damask linen* is an eight-shaft satin construction on the Jacquard loom. There are twice as many filling yarns as warp yarns, which gives greater distinctness to the pattern; the cloth count ranges from 165 to 400 to the inch.

Originally, double-damask linen was considered superior to single damask. This is no longer true. Today, the weave alone does not produce a superior product, because inferior yarns as well as high-quality yarns are used in all weaves. Double damask may range in quality from mediocre to excellent, and may be regarded as superior to single damask only if good yarns and quality construction are used.



Double damask is superior to single damask only if good yarns and quality construction are used.

If single and double damasks having cloth counts approximately the same are compared, the single damask is preferable because shorter floats give greater serviceability. The threads hold more firmly. A double damask with a cloth count less than 180 threads is not advisable for home use.

**Finishing Linen.** Linen is usually bleached in the piece, except yarns for dress linens. Two methods of bleaching are used. *Grass bleaching* produces the finest results. *Chemical bleaching* is chiefly used, but it may adversely affect the durability of the finished cloth.

The bleaching process produces four grades in the finished product: fully bleached, three-quarters bleached, half or silver bleached, quarter bleached. Unbleached linen makes a fifth grade.

A fully bleached linen fabric is less enduring than any other grade. Unbleached linen is the strongest because the natural strength of the fiber has not been weakened by the bleach; it is sometimes called gray linen or brown linen.

The natural characteristics of linen are enhanced by such finishing processes as:

Sizing—for added body.
Mercerizing—for luster.
Beetling—for softening and uniform thickness.
Calendering—for luster and smoothness.

Linen is never napped. The fiber does not lend itself to this process, nor would napping be desirable for long-staple yarns of hard surface.

Grass bleaching produces finer results than chemical bleaching.

Where some crease resistance is obtained by reducing the yarn to short staple, the chief attribute of linen—strength—is sacrificed. Thus, any fuzziness in a linen fabric indicates the use of short staple or the presence of cotton.

**Dyeing Linen.** Linen is seldom yarn-dyed. The surface of the flax fiber is hard and nonporous, and is therefore impenetrable to dyes. The cells of the fiber are held together with tissue that can be broken down only in a severe bleaching process. Therefore, highly colored linens will not give lasting service because they must have been fully bleached in order to absorb the dye.

**Judging Linen Fabrics.** The term "linen" has long been used to refer to such household necessities as tablecloths, napkins, towels, pillowcases, sheets, and decorative cloths. Every consumer knows that these articles are not necessarily made of pure linen. They may be made of cotton or spun rayon, even of linen mixed with such fibers. However, it is always a woman's ideal to possess pure linens because they satisfy a craving for the beautiful and the luxurious, and may remain in families as heirlooms.

When linens are chosen wisely, their additional cost is well worth while. There is no doubt that linen is still the best fabric for table covering because of its durability as well as its exceptional beauty when thus displayed.

*Pure Linen.* Even when a fabric is labeled "pure linen," it is necessary to know whether the yarns are line or tow. Fine linen fabrics, such as high-grade table damask and dress linens, are usually made of line, the long, uniform staple. Line may be distinguished from tow by untwisting and examining the length of the fibers. The popular peasant linen is made of tow, but it is constructed with a very fine weave.

Pure linen is free from lint; therefore, the presence of lint indicates adulteration with cotton, or possibly oversizing. Cotton yarns are frequently mixed with linen to produce inexpensive fabrics. The name "Union Linen" is given to a fabric of which half or more is cotton. Linene is a trade name for an all-cotton fabric that simulates linen.

*Strength.* Linen is especially durable, being second in strength to silk. As a textile fabric, it wears well and lasts for a long time.

*Sizing.* As excessive sizing indicates the probability of poor construction or imperfections in weave, a sample may be tested for oversizing by holding it to the light, by rubbing, or by washing.

*Weight.* In linen, weight may be considered a criterion of durability. Damask weighs from 4 to 7 ounces to the square yard.

*Crease Resistance.* The inelasticity of the flax fiber causes linen to wrinkle easily, which somewhat offsets its otherwise excellent qualities as a fabric for summer apparel. But it is possible to buy dress linens that have been given one of the patented crease-resistant processes described in Chapter V.

*Heat Conductivity.* Linen is most suitable for summer apparel, as it allows the heat of the body to escape.

*Absorbency.* When absorbency is the main consideration, linen is preferable to cotton. It absorbs moisture and dries more quickly than any other fabric. It is therefore excellent for handkerchiefs and towels.

*Cleanliness and Washability.* Linen launders well and gives up stains readily; its softness is enhanced with repeated washings. Linen can be boiled and made absolutely sterile. It is desirable for surgical dressings and bandages. Bacteria do not thrive on linen because of its hard, smooth surface.

*Shrinkage.* Linen does not shrink a great deal.

*Fastness of Color.* When buying colored linens, look for the words "Guaranteed Fast Color" on the label, or get a guarantee of colorfastness from the store. If a label states that the fabric is vat-dyed, it has been given the fastest color possible to withstand washing.

*Resistance to Mildew and Moths.* Like cotton, linen is vulnerable to mildew; but moths will not eat linen.

### Glossary of Linen Fabrics [1]

**Art linen.** Closely woven round-thread linen, used chiefly for embroidery, generally in the plain weave. Bleached, unbleached, and colors. Also used for dresses and table linens.

**Bisso linen.** Fine, sheer linen; sometimes called altar linen. Made of wiry yarns. Has a crisp feel. Used for altar cloths.

**Cambric.** Fine, closely woven fabric with a high cloth count. Plain weave; white and colors. Used chiefly for handkerchiefs.

**Canvas.** Many fabrics come under this heading. Two principal types: (1) Open-mesh canvas. Used for embroidery. Made of hard-twisted yarns. Very durable. Most popularly known in this group is Java canvas. (2) Close-woven canvas. Made from coarse hard-twisted yarns in the plain weave. Comes in various weights. Finishes range from heavily sized to soft.

**Crash.** A relatively coarse fabric made of uneven slack-twisted yarns. Made in various qualities; plain weave. Used for towels, suitings, dresses, depending on the weight.

**Damasks.** In satin weave as well as the Jacquard pattern. Two types: single damask and double damask. Single damask has a five-shaft satin construction. If given a high cloth count, is more durable than double damask. Double damask is more lustrous because of the longer float of the eight-shaft construction; it is reversible because the design is made on both sides.

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[1] Specially prepared by the Linen Trade Association.

**Handkerchief linen.** Same as linen cambric. Sometimes called linen lawn or linen batiste. Plain weave, often corded.

**Huckaback.** Coarse fabric, having a rough surface. Many variations in weave; may have small figures. Colors range from semibleached to white.

**Sheeting.** Firmly constructed plain-weave cloth. Used industrially. The closer constructions used for bed linens. May be unbleached or white.

**Toweling.** General name that covers all types of linen woven in special widths for towels. Some are terry, huckaback, crash, bird's-eye, glass.

*Test yourself on this chapter by answering these questions:*

1. Why is linen a desirable fiber?
2. Why is linen not used so frequently as cotton?
3. What disadvantages may there be in the use of linen fabrics?
4. Why are linens expensive?
5. What kind of climate is necessary for the growth of flax?
6. What are the methods of retting? Which method is used in Russia? In Ireland? In Belgium?
7. Which method of retting produces the finest linen?
8. From what part of the flax plant is the fiber taken? From what part of the cotton plant is the fiber taken?
9. What are line and tow?
10. Would you prefer a cotton blouse to a linen blouse? If so, why?
11. What country grows the flax plant for its seeds? What are the seeds used for?
12. Why should the short fibers be separated from the long fibers? What process accomplishes this?
13. What characteristic of the linen fiber makes it difficult to spin? How would a wet fiber be more easily twisted?
14. In what weaves are linen yarns woven? Name some fabrics in each weave.
15. What finishing processes are given to linen fabrics?

## Suggested Readings

Caplin, J., *Linen Fabrics.*

Dooley, W. H., *Textiles,* Chapters 18, 19.

Dyer, E., *Textile Fabrics,* Chapter 7.
Hess, K. P., *Textile Fibers and Their Use,* Chapter 5, Section 2.
Matthews, J. M., *The Textile Fibers,* Chapters 12, 22.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 5.
Moore, A. S., *Linen.*
Nystrom, P. H., *Textiles,* Chapter 9.
Small, C. P., *How to Know Textiles,* Chapter 13.
Wingate, I. B., *Textile Fabrics,* Chapter 5.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 9.

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## CHAPTER X

# WOOL: WARM AND RESILIENT

Originally, wool was borne on wild species of sheep as a short, fluffy undercoat concealed by hair. When wild sheep were killed by primitive man for food, the pelts were used as a form of covering for his body. The fluffy undercoat probably became matted by usage, thus giving early man the idea of felting it into a crude cloth. It is believed that ancient shepherds in the first century A.D. discovered that Merino sheep could be bred to improve the fleece.

At first, wool was a very coarse fiber. Its development into the soft, fleecy coat so familiar on domesticated sheep is the result of long-continued selective breeding; the quality has been greatly improved by careful crossbreeding of fine-wool and long-wool sheep.

The breeding of the animals and the production of the wool fiber into cloth are more costly processes than the cultivation of plant fiber and its manufacture. Consequently, wool fabrics are more expensive than cotton and linen ones. But wool provides warmth and physical comfort that no other fabric can give so completely. These qualities, combined with its soft resiliency, make wool a necessity for apparel as well as for such household uses as rugs and blankets.

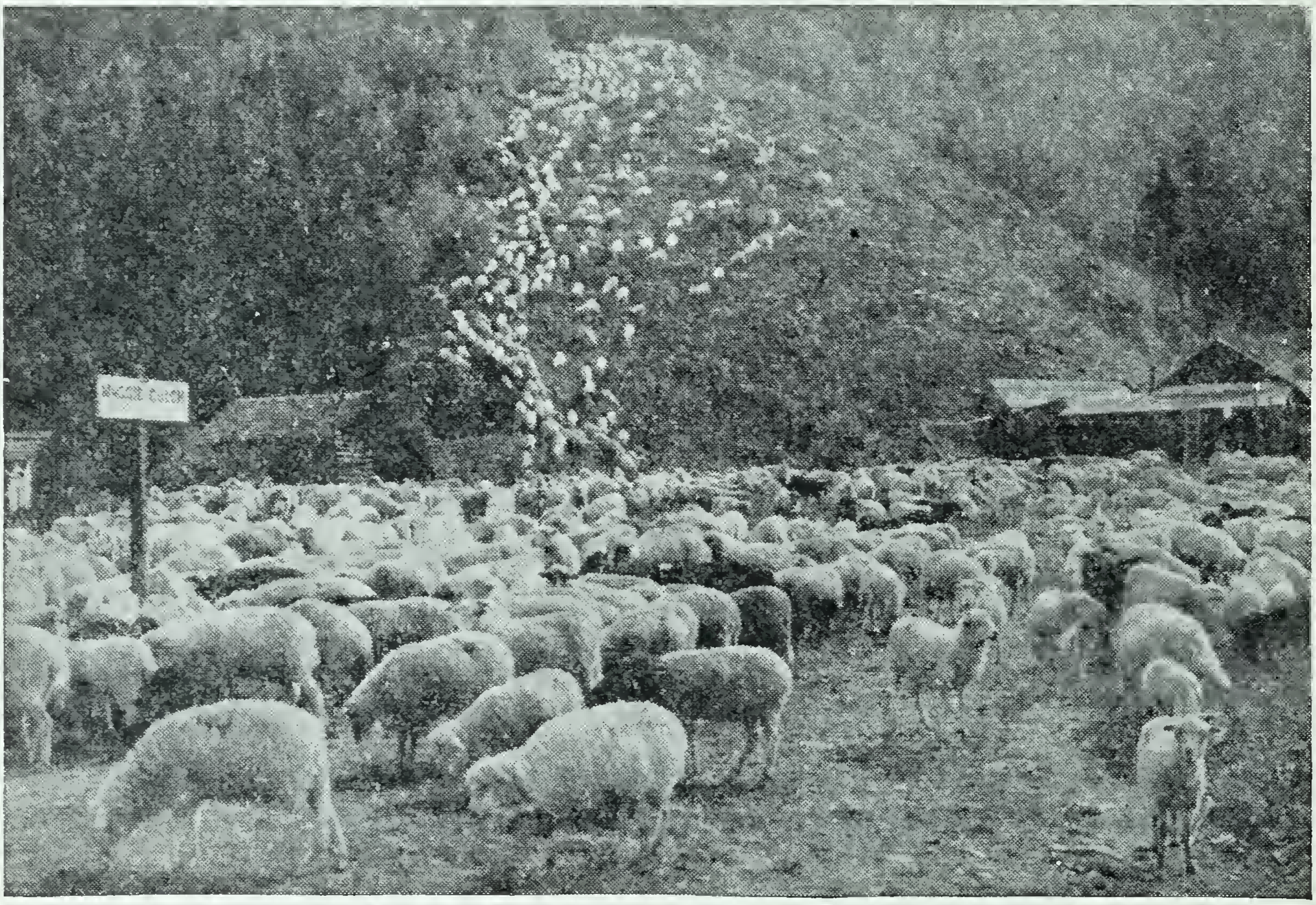
Wool is not overabundant; the factor of scarcity adds to its value. Wool is also a delicate fiber. This makes intelligent buying and care more than ever a responsibility that the consumer must assume if he wishes serviceability and durability.

**Wool and Hair.** Wool fiber and hair fiber differ in basic structure. Wool is distinguished from hair by its overlapping scales, which give wool fiber its felting property. Hair is straight, lustrous, and comparatively inelastic; it is stronger and smoother than wool.

Strictly speaking, such animal hairs as camel's hair, mohair, cashmere, llama, alpaca, and vicuna differ enough from wool to be classified as *hair fibers*. However, as these hairs are included by the United

States Government under specification standards for wool fabrics, these hairs are described at the close of this chapter. They have all the qualities of wool. In general, they are even more expensive than wool. Vicuna is the world's costliest textile product and surpasses all other textiles in fineness and beauty. These hairs are often mixed with wool, adding rather than detracting from the quality of any wool fabric in which they appear.

**Wool-producing Countries.** The quality of the wool fiber is determined by the breeding, climate, food, and general care and health of the sheep. Cold weather produces a hardier and heavier fiber; excessive moisture dries out natural grease; insufficient or poor food retards growth.



Sheep grazing.

Certain countries are more suitable than others for large-scale sheep raising and consequently produce the greatest quantities of wool. These wool-producing countries are ranked here according to statistics provided by the United States Department of Agriculture. These figures may be considered as representative for a normal year.

| | *Pounds* | | *Pounds* |
|---|---|---|---|
| Australia | 975,000,000 | British Isles (excluding Irish Free State) | 108,000,000 |
| United States | 426,000,000 | | |
| Argentina | 373,000,000 | India | 84,000,000 |
| South Africa | 264,000,000 | Other countries | 1,462,000,000 |

**Classification of Sheep Bred for Wool.** Only a few types of sheep are of value for their wool. These are the Merino, long-wool, mutton, and crossbreed.

*Merino sheep* produce the best wool. The staple is relatively short, ranging from 1 to 5 inches; but the fiber is strong, fine, and elastic, and has good working properties. There are a maximum number of serrations, totaling as many as 3,000 to the inch. Merino is used in the best types of wool clothing. The Ohio Merino, Austrian Silesian, and the French Rambouillet are all Merino sheep. Other types are now found in Australia, New Zealand, South America, South Africa, and Spain.

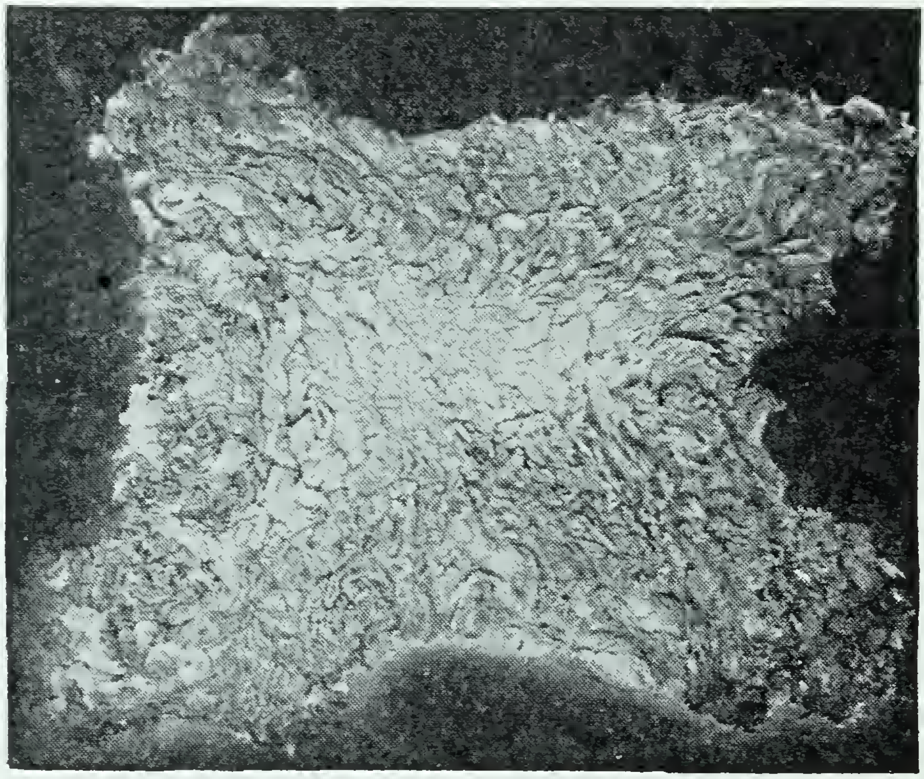
*Long-wool sheep* produce a long staple, ranging from 4 to 18 inches, which is used for clothing and some floor coverings. Some of the better-known sheep yielding long wool fiber are the Lincoln, Leicester, Cotswold, Cheviot, Shetland, Harris, and others from the British Isles. Many wool fabrics used today are named according to the type of sheep from which their fiber was obtained.

*Mutton sheep* are those bred in all parts of the world chiefly for meat. Their fiber is of secondary importance. Wool fiber from mutton sheep is short, coarse, and of inferior quality, but of great significance in the low-price clothing market. Its total production exceeds any other type.

*Crossbreed sheep,* as far as the wool industry is concerned, are the result of interbreeding the Merino type with mutton sheep. The amount of Merino strain in the crossbreed is indicated by such terms as "half blood" and "three-quarters blood." Crossbreed sheep are also known as half-breed or mongrel sheep; their fiber is irregular, ranging from 1 to 16 inches, and is used for carpets and for inexpensive wool clothing.

**Classification of Fleeces.** Sheep are generally shorn of their fleeces in the spring; but the time of shearing naturally varies in different parts of the world. In the United States, shearing takes place in April or May; in Australia, in September; in Great Britain, in June or July. Although sheep are normally shorn only once a year, Texas and California sheep are shorn twice a year because of the warm climate.

Sheep are not washed before shearing. Sometimes they are dipped into an antiseptic bath, but this is done only when prescribed by law. Formerly, sheep were shorn by hand, but today the fleeces are removed in one piece by machine clippers, which shear closer as well as faster than the hand clippers.



A fleece after shearing.

Wool shorn from young lambs differs in quality from that of older sheep. Also, fleeces differ according to whether they come from live or dead sheep. This necessitates standards for the classification of fleeces.

*Lamb's Wool.* The first fleece sheared from a lamb about six to eight months old is known as *lamb's wool,* or *first clip.* This wool is of very fine quality; the fibers are tapered because the ends have never been clipped. Such fibers produce a softness of texture in fabrics that is characteristic only of lamb's wool.

*Hog or Hogget Wool.* Fleeces from sheep twelve to fourteen months old are called *hogget wool*; this fiber is also fine, soft, and resilient.

*Wether Wool.* Fleeces clipped from sheep older than fourteen months are called *wether wool.* These fleeces contain much soil and dirt.

*Pulled Wool.* When sheep are slaughtered for meat, their wool is pulled from the pelt by the use of lime, by sweating or by a chemical depilatory. Such wool fiber, called *pulled wool,* is of inferior quality because the roots of the fibers are generally damaged by the chemicals and the tension exerted in pulling.

*Dead Wool.* The grade of wool fiber known as *dead wool* is sometimes mistaken for pulled wool. The term is correctly used for wool that has been recovered from sheep that have died on the range or that have been accidentally killed. Dead wool fiber is decidedly inferior in grade; it is used in low-grade cloth.

*Taglocks.* The torn, ragged, or discolored parts of a fleece are known as *taglocks.* These are usually sold separately as an inferior grade of wool.

**Government Classification of Wool.** There has never been a sufficient supply of new wool stocks to take care of a steadily increasing demand for wool. To meet this situation, wool fibers have had to be recovered from old clothing, rags of all kinds, and waste from wool manufacturing; all are important sources.

This wool is variously called "salvaged," "reclaimed," "reworked," or "remanufactured," but it is best known in the textile industry as *shoddy.* This term is misunderstood by the average consumer, who is inclined to believe that wool fabric containing remanufactured fibers is necessarily of inferior quality. This is not so.

As wool fiber is the weakest of the major textile fibers, the hardier though less resilient remanufactured fibers, when obtained from good original stock and combined with new wool from lamb, hogget, or wether fleeces, add durability to the soft new wool. Thus, remanufactured fibers contribute ability to withstand hard wear, although there is some sacrifice in warmth, softness of texture, and resiliency.

The use of remanufactured fibers also makes wool clothing available to consumers who cannot afford expensive wool fabrics.

To correct wrong impressions concerning the use of remanufactured wool, and also to protect consumers against unscrupulous practices, the United States Government passed the Wool Products Labeling Act. This act provides that every article of wool clothing must be labeled according to the type of wool used in its manufacture. The label must state: (1) the amount of wool fiber in the fabric; (2) the percentage by weight of "new or virgin wool" fibers; (3) percentages of "reprocessed" fibers or "reused" fibers; (4) the percentage of each fiber other than wool, if such fibers constitute 5% or more of the total; (5) the aggregate of other fibers; (6) nonfibrous loading, filling, or adulterating substance.

New definitions of the type of the wool fibers used in labeled garments were established by this act. The following descriptions are in accordance with Government specifications.

1. *Wool.* The simple term *wool,* according to Government standards, must always mean *new wool* that has not been made up in any form of wool product. New wool comes directly from a fleece. It has never been previously woven, felted, or worn.

2. *Reprocessed Wool.* According to the Government classification, *reprocessed wool* is fiber that has been reclaimed and remanufactured from *unused* wool materials. Such materials may be combings and scraps of wool obtained during the manufacturing processes, sample swatches, or pieces of all-wool cloth from apparel manufacturing.

3. *Reused Wool.* The Government gives the special classification of *reused wool* to fiber that is salvaged from all kinds of *used* consumers' goods.

**Virgin Wool.** The term *virgin wool* is now used by the textile industry to designate new wool from a sheep's fleece, but the term is too all-inclusive to serve as a criterion of quality. Although the term testifies to the fact that virgin wool does not contain remanufactured wool fibers, it can be used to identify the less desirable fibers of a fleece as well as a specially fine quality of lamb's wool. Virgin wool may also include pulled or dead wool, which may be of definitely inferior stock.

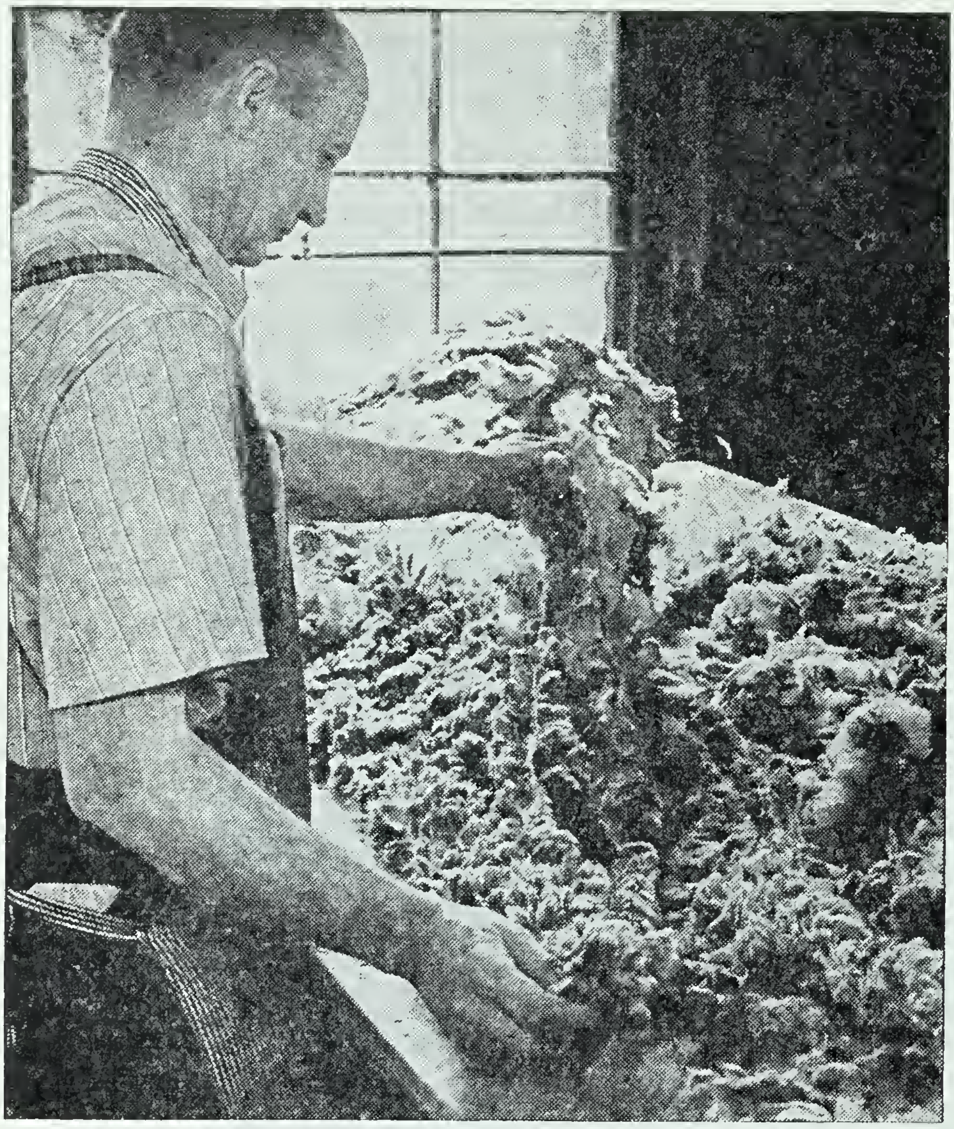
The consumer should not feel that a fabric labeled "100 per cent new wool" is necessarily more serviceable than one containing any of the remanufactured wool fibers, for there are many different grades of new wool. It is important to remember that a high grade of reprocessed wool makes a more serviceable fabric than one having a low grade of new wool. This is attested to by the fact that after stringent tests the United States Army prefers overcoat material made of 65 per cent new wool and 35 per cent reprocessed or reused wool.

**Garnetting.** Reprocessed and reused wool fibers are obtained by separately reducing the unused and used materials to a fibrous mass by a picking and shredding process called *garnetting.* The fibers are then put through a dilute solution of sulphuric or hydrochloric acid, which destroys any vegetable fibers that may be contained in the raw stock. This process is known as *carbonizing,* and the resultant wool fibers are called *extracts.* The new staple ranges from ¼ to 1½ inches in length.

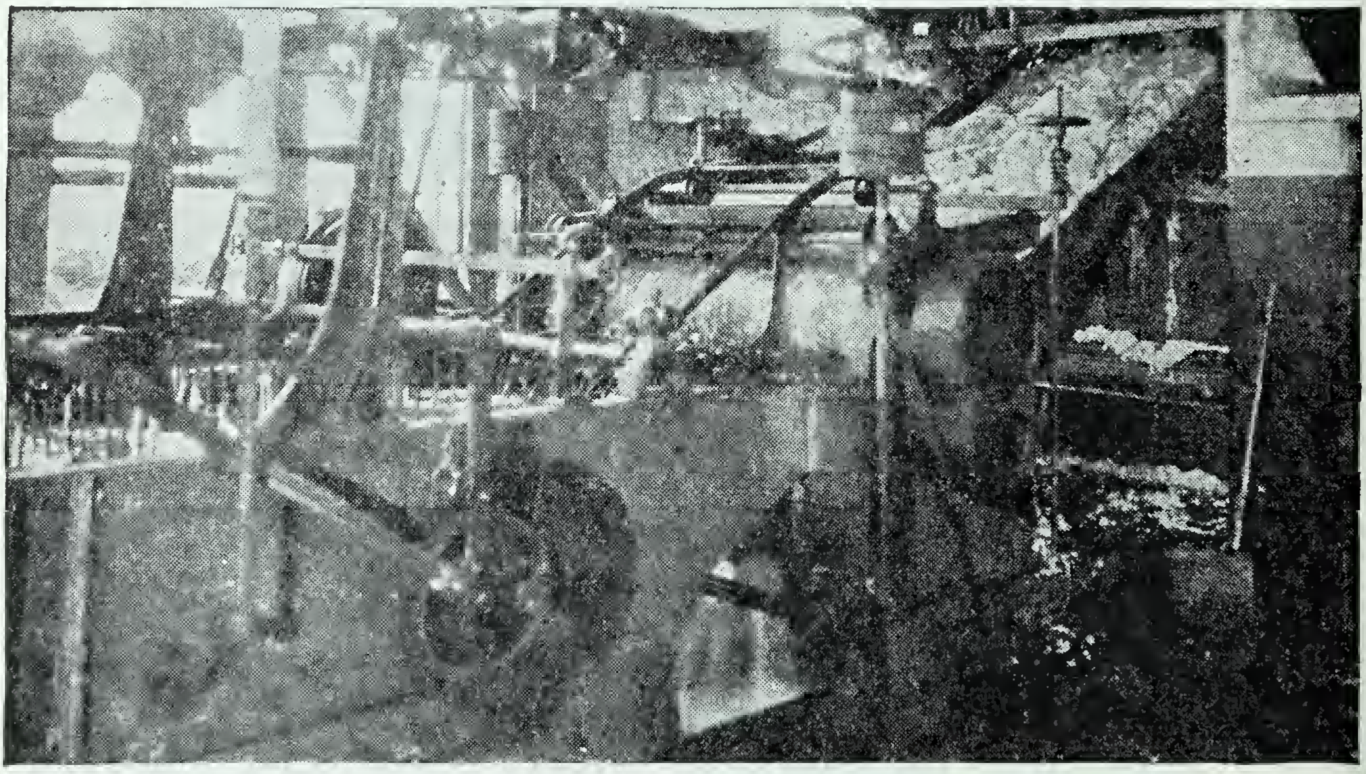
Fine-quality virgin wool received at the mill to be spun into yarn.

The quality and cost of reprocessed and of reused wool fibers depend on the original stock from which they were obtained. A good grade of reprocessed wool may cost five times as much as a poor grade of virgin wool.

**Preparation of Wool Fiber.** Domestic wool reaches the mill in loosely packed bags; imported wool comes in tightly compressed bales. Each fleece contains different grades or *sorts* of wool, and the raw stock must be carefully graded and segregated according to length, diameter,



*Left:* Rigid sorting of wool by skilled workers may produce as many as twenty grades.

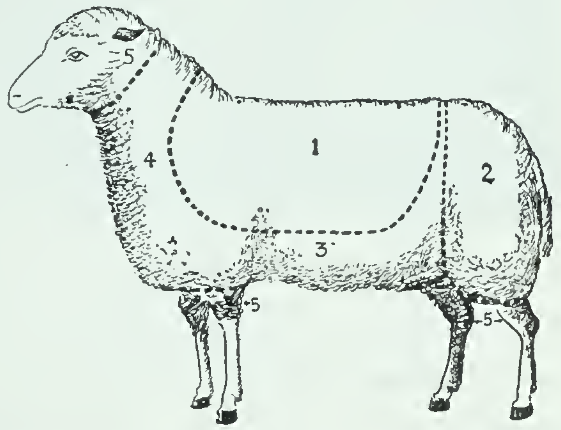


The scouring machine washes wool fiber. Automatic rakes stir the wool during the process, and rollers squeeze out the water.

and quality of the fiber. The raw wool or newly sheared fleece is called *wool in the grease* because it contains the natural oil of the sheep. When wool in the grease is washed, it loses from 20 to 80 per cent of its original weight. The grease, known as *yolk* or *suint,* is used for lanolin compounds, which are valuable because they can be absorbed by the human skin. Lanolin is widely used in the medicinal and cosmetic industries.

*Sorting.* Wool sorting is done by skilled workers who are expert in distinguishing qualities by touch and sight. As many as twenty separate grades of wool may be obtained from one fleece if the sorting is especially rigid. Each grade is determined by type, length, fineness, elasticity, and strength.

Wool from different parts of the body of the sheep differs greatly. The sides and shoulders generally yield the best quality of wool as the fibers from those parts are longer, softer and finer. The next best quality comes from the back and upper part of the hind legs.



One fleece produces different qualities of wool fiber. The parts are here numbered according to the softness, fineness, and length of fiber, No. 1 yielding the best quality.

*Scouring.* The next step in preparing raw wool for manufacturing is a thorough washing in an alkaline solution; this process is known as *scouring.* The scouring machines contain warm water, soap, and a mild solution of soda ash or other alkali; they are equipped with automatic rakes, which stir the wool. Rollers between the vats squeeze out the water. If the raw wool is not sufficiently clear of vegetable substance after scouring, it is put through the carbonizing bath of dilute sulphuric acid or hydrochloric acid.

For some consumers' goods the term "naphthalated wool" is used, which means that the grease and dirt found in the fleece when originally sheared from the sheep's back have been removed by a series of naphtha baths, followed by clear water which removes the naphtha. When wool has been thus treated by a cleansing agent, dyestuff penetrates better.

*Drying.* Wool is not allowed to become absolutely dry. Usually about 12 to 16 per cent of moisture is left in the wool to condition it for subsequent handling.

*Oiling.* As wool is unmanageable after washing, the fiber is dipped in a light emulsion of virgin olive oil or mineral oil to prevent it from becoming brittle and to lubricate it for the spinning operation.

**Dyeing.** If the wool is to be dyed in the raw stock, it is dyed at this stage. The advantage of stock dyeing has been described in Chapter VI. Some wool fabrics are piece-dyed.

**Blending.** Wool of different grades may be blended or mixed together at this point. It is not uncommon for taglocks and inferior grades of wool to be mixed with the better grades. The use of a mixture with a coarser grade of fiber is a legitimate practice if the purpose is to make a hardier product and a less expensive one, provided the label on the finished goods indicates a true description of the raw materials used.

In the manufacture of "Union" fabrics, a small amount of cotton is blended with raw wool. A greater amount of twist can be given to such yarns, with a resultant increase of strength in the fabric. Peruvian cotton is frequently mixed with raw wool stock. Such mixtures have a place in certain finished goods, but the amount of cotton used must be indicated on the label.

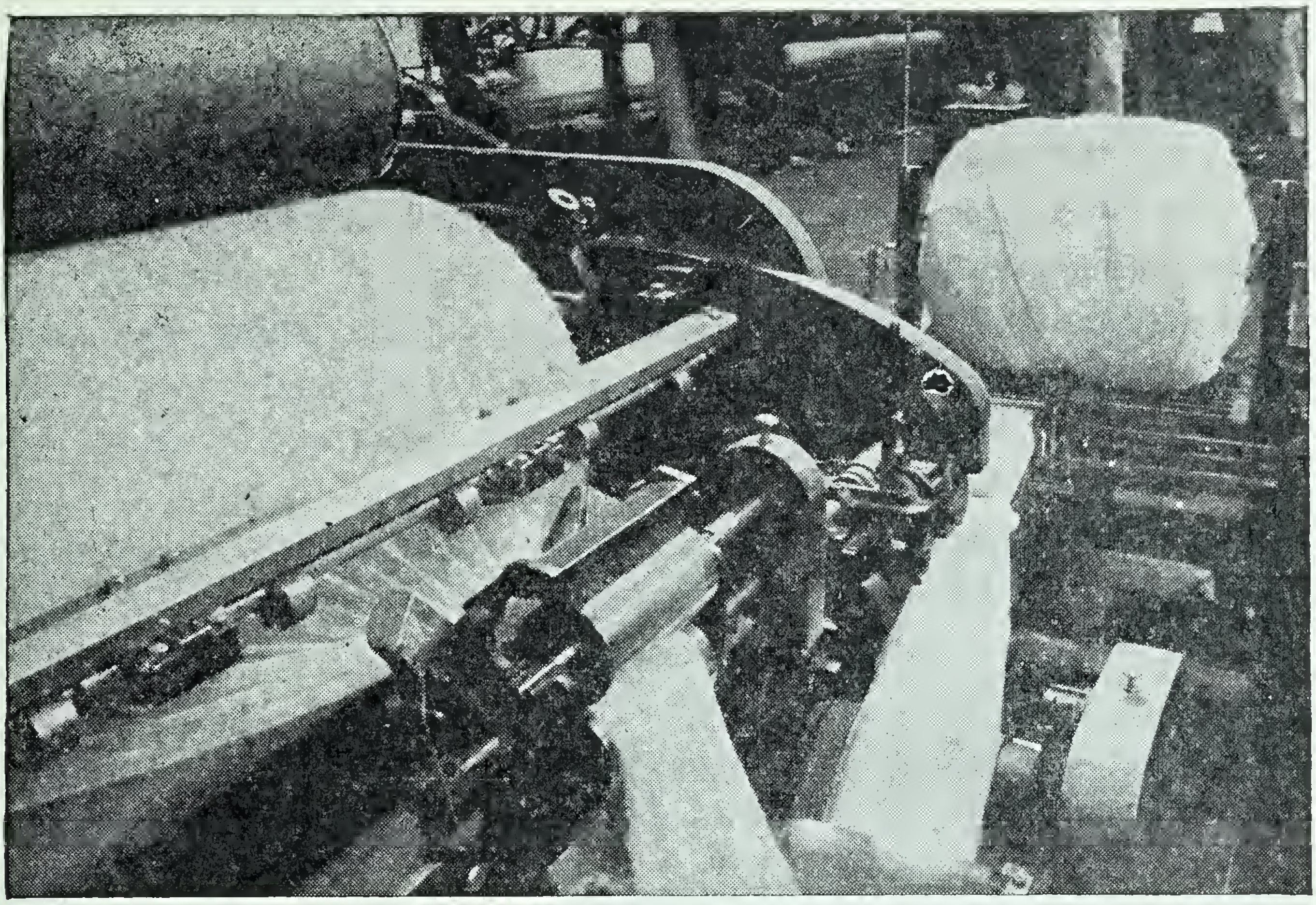
**Carding.** The carding process introduces the classifications of *woolen yarns* and *worsted yarns.* Manufacturing processes from this point differ, depending on whether the wool fiber is to be made into a woolen or a worsted product.

The length of staple and its strength determine the use of the fiber. Carding machines align the wool fibers, separating the short from the long staple, by means of cylinders covered with cloth through which the ends of tough wires protrude.

The shorter fibers, from 1 to 4 inches in length, are called *carding wools,* sometimes referred to as *clothing wools.* They are generally used in the manufacture of such woolens as shetland, flannel, cheviot, and tweed.

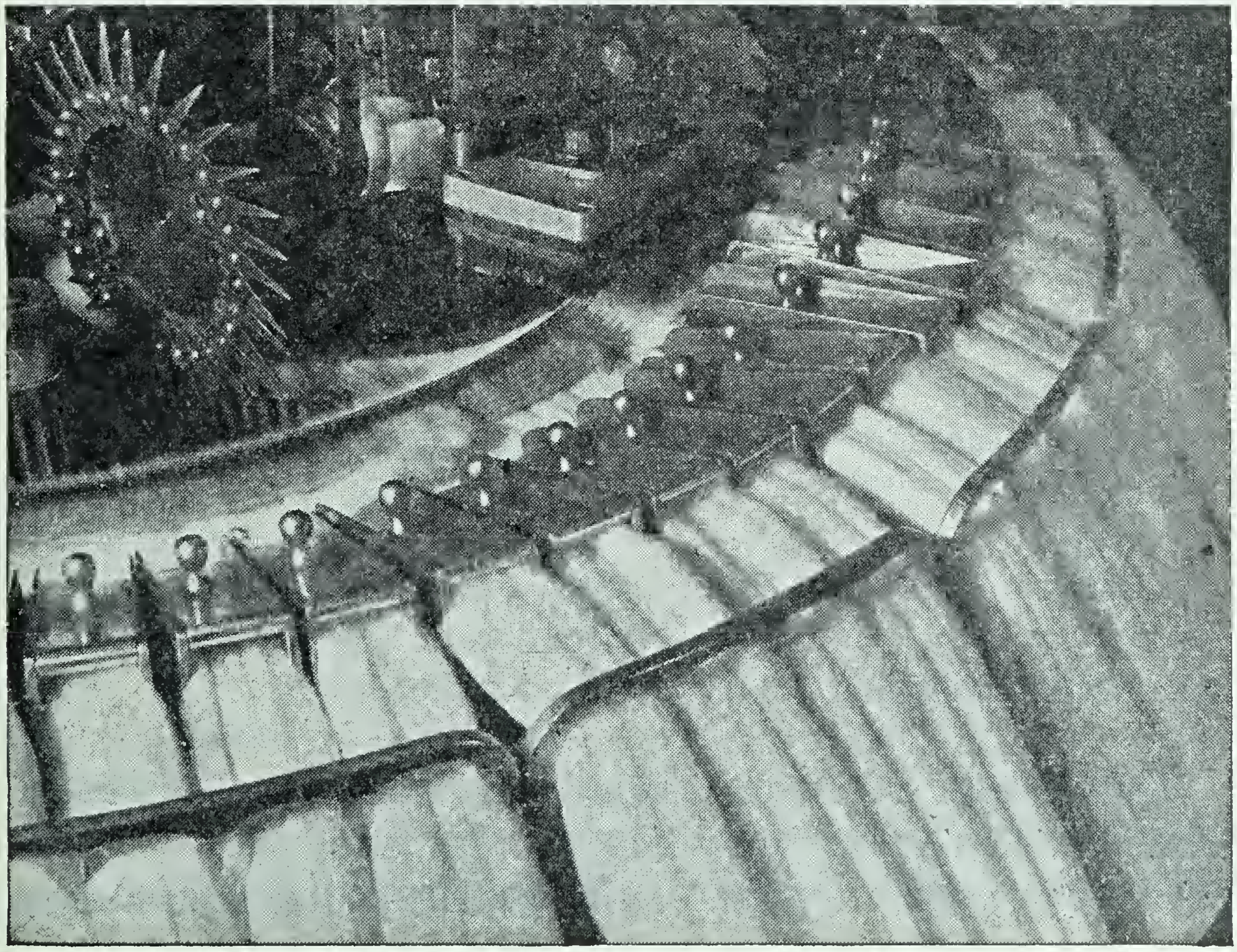
Fibers of very short staple, which are coarse, harsh, and wiry, are called *carpet wools.* They are suitable for carpets and are also used for coarse wool blankets.

The shortest fibers, called *noils,* are removed in the carding process.



*Above:* Carded wool coming from the cylinder (at the left) in fine spider-web form is being drawn into wool sliver.

*Below:* The Noble comb, shown here in operation, produces the finest long-staple wool.



These fibers are used as filler in woolen fabrics made of reprocessed wool, helping to produce a sturdier cloth.

The long staple is reserved for worsted yarns, which require additional combing processes.

**Combing.** The carded wool is put through a gilling operation, which straightens and elongates the fibers and eliminates the shorter staple, called *combing noils.* Combing noils are of good quality and can be used as filler for other types of wool fabrics.

The long-staple fibers, called *combing wools,* are over 4 inches in length and excel in color, feel, and strength. They are used in the production of such worsted fabrics as serge, whipcord, gabardine, and covert.

**Spinning.** In the spinning operation, the wool roving is drawn out and twisted into yarn. Woolen yarns are chiefly spun on the mule spinning machine. Worsted yarns are spun on any kind of spinning machine—mule, ring, cap, or flyer.

There are two different systems of spinning worsted yarns.

1. In the English system (Bradford), the yarn is oiled before combing, and a tight twist is inserted. This produces smoother and finer yarns. The more tightly twisted yarn makes a stronger, more enduring fabric.

2. In the French system, no oil is used. The yarn is given no twist; it is fuzzier, and therefore suitable for soft worsted yarns.

The differences between woolen and worsted yarns are summarized as follows:

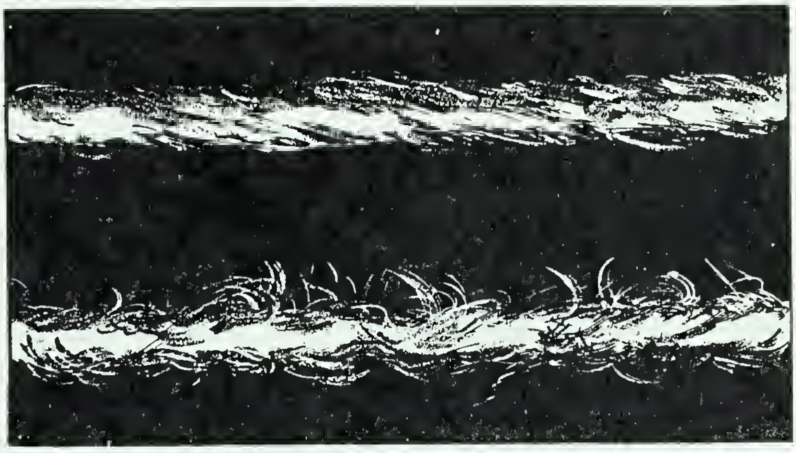
| *Woolen Yarn* | *Worsted Yarn* |
|---|---|
| Short staple | Long staple |
| Carded only | Carded and combed |
| Slack twist | Tightly twisted |
| Weaker | Stronger |
| Bulky | Finer, smoother, even fibers |
| Soft | Hard |
| Uneven twisting | Even twisting |

**Yarn Count.** The fineness or thickness of wool yarns is based on different systems for woolen and worsted. One pound of worsted yarn yielding 560 yards is identified as No. 1s. Ply yarns are numbered according to the number of the single yarn from which they are spun. Thus, 2/60s worsted means two-ply yarns of No. 60 singles, twisted together.

In woolens, the size of the yarn is based on two separate systems: the cut, and the American run. The latter is more generally used.

The *cut system,* sometimes called the Philadelphia because of its use in that area, uses a base of 300 yards to the cut. Thus, 1 pound of woolen fiber drawn out to 300 yards sets a standard for No. 1s.

In the *American run system,* sometimes called the New England, 1 pound of woolen yarn yielding 1,600 yards is identified as No. 1s.



Long-staple fibers produce the smooth worsted yarn shown in the upper part of this drawing. Short-staple fibers produce an uneven yarn with protruding short ends, as in the lower drawing.

**Warping.** The yarn that leaves the spinning frame is not of sufficient length to serve as warp yarn on the loom. It is first wound on bobbins or spools and placed on a large rack or frame called a creel.

As in the warping operation explained in Chapter III, the warp yarns on the bobbins or spools are evenly wound on the warp beam. They may be immersed in a solution of starch, gum, or similar compound in order to make them smooth and strong for weaving.

In the production of better-quality wool fabrics, a hard-twisted two-ply yarn is frequently used for the warp yarn, as the plied construction gives greater strength.

**Weaving Woolen Fabrics.** Basically, the weaving process for wool resembles the process described in Chapter IV. The short, curly woolen yarns obtained in the carding process are made into woolen fabrics by using the plain weave, sometimes the twill. The weave pattern is not discernible as woolen fabrics have a napped surface.

The cloth count of woolens is usually less than that of worsteds, as the construction is not so compact.

Woolen fabrics are soft, fuzzy, and thick; they are warmer than worsted, but not so durable. Napping gives woolens a soft surface, which acts as a protection against objectionable luster. But napping can conceal poor construction and the quality of the yarns used; therefore, woolens can be more easily adulterated than worsteds. The napped surface tends to catch and hold dirt, but stains can be easily removed.

If poorer yarns have been used in woolens, the fabric is less expensive than worsted. Woolens are desirable for sportswear, jackets, sweaters, skirts, blankets, and similar general use.

**Weaving Worsted Fabrics.** The worsted yarns, which have been specially carded and combed, are woven into fine worsted fabrics with distinctive patterns, chiefly by means of the twill weave. The plain weave is infrequently used. The cloth count of worsteds is higher than that of woolens because the finer yarn is more closely constructed.

Worsted fabrics are flat, rough, and harsh when worn next the skin. They are more durable than woolens and more resistant to dirt. They wrinkle less and hold creases and shape, but they become shiny with use.

Worsted fabrics are costlier than woolens. They are appropriate for tailored and dressy purposes, for spring and summer coats and suits, and for tropical suits. They are suitable for business wear.

In order to obtain the advantages of both woolen and worsted types, worsted yarns may be used as warp, and woolen yarns as filling, thus producing *unfinished worsted.* Unfinished worsteds are popular because they have the durability and tailored appearance characteristic of worsted fabrics, and the comfort, greater warmth, and freedom from shine characteristic of woolens.

**Fulling.** After the weaving process, woolen and worsted gray goods are placed in warm, soapy water, and are pounded and twisted in order to make the wool fibers interlock. This application of heat, moisture, and pressure, followed by a cold rinse, is called *fulling* (also *felting* or *milling*). Sometimes chemicals are used to help moisten, soften, and lubricate the minute fibers so that matting will occur.

Fulling produces a desired shrinkage and gives the fabric additional thickness and a firmer, fuller texture. The longer the fulling operation, the greater the shrinkage, with consequent increase in the strength of the fabric.

The fulling process and other finishing operations for woolens and worsteds yield *flocks,* extremely short staple ranging from ⅛ to ¾ inch in length. Flocks are felted into the poorer grades of woolens in order to add weight. They are also blended with other raw wool stocks.

Other waste material reclaimed from fulling is termed *mungo.* This is the lowest grade of waste; it is used for blending, and is combined with yarn for low-grade wool fabrics.

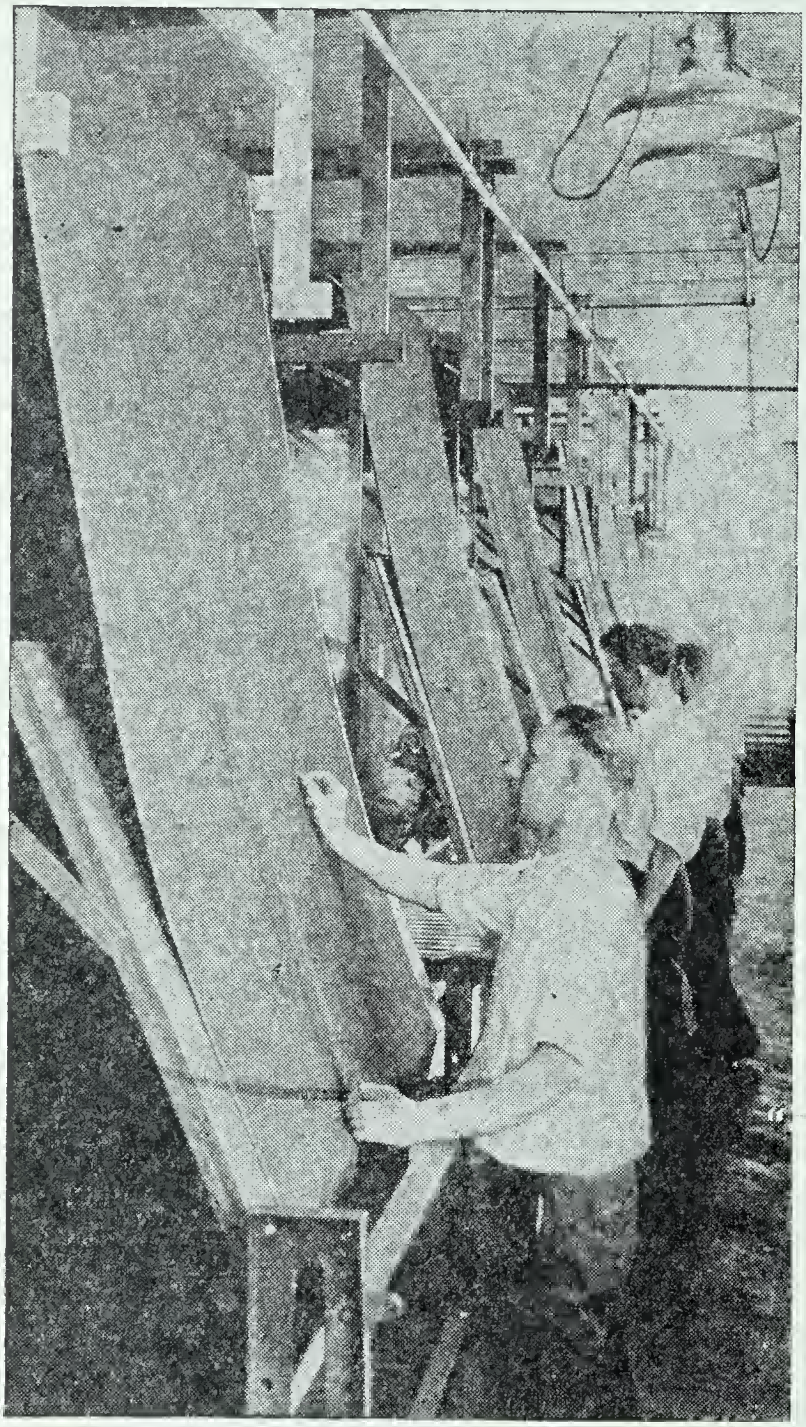
**Crabbing.** To set the cloth and the yarn twist permanently, wool fabric is passed over several cylinders that rotate in hot water and is then immersed quickly in cold water. The cloth is held firmly and tightly to avoid wrinkling. Repetition of the treatment with increased pressure results in setting the cloth and the finish.

**Additional Finishing Processes.** Wool fabrics are also given the following finishing processes:

Perching—examining cloth for defects while it is run over two rollers.
Burling—removing loose threads and knots.
Mending—darning flaws and defects, if any.
Shearing—cutting and shaving for a uniform surface.
Singeing and steaming—for the characteristic hard finish of worsted fabrics.
Pressing—improving appearance and giving final shape to the cloth.
Steaming, sponging, or shrinking—removing excess glaze, setting cloth to proper width.
Decating or decatizing—may be done wet or dry, a shrinking operation in conjunction with cylinder shrinking. In decating, the cloth is shrunk by winding it under tension on a perforated cylinder through which steam is then forced. The process frequently serves as a substitute for London shrinking.

**Judging Wool Fabrics.** The presence of reprocessed or of reused wool in a fabric does not condemn it so long as the product is properly labeled and the consumer understands the limitations as well as the advantages of such wool fabrics. A fabric made of new or virgin wool may be of inferior quality if it is made of inferior grades or extremely short staple.

*Strength.* As wool is the weakest of the major textile fibers, the fabric is made more durable by the use of selected grades of reprocessed or reused wool, although the durability is gained at the expense of texture and resiliency. To determine whether strength has been given by the use of flocks, brush and whip the fabric vigorously. Then examine the surface and selvages for powdery particles, which are the signs of short staple.



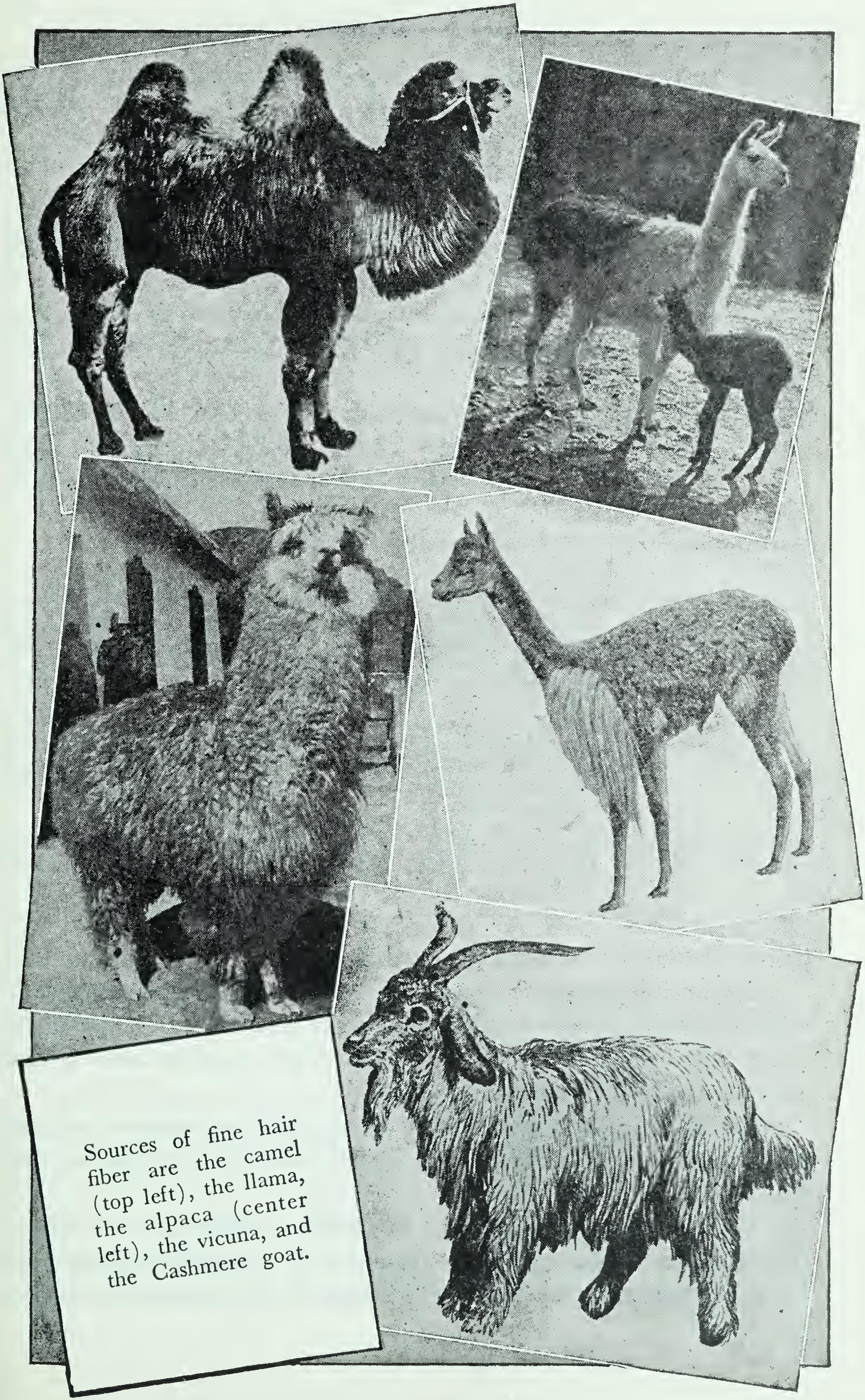
Under strong light, wool fabrics are pulled over high rollers to undergo a rigid inspection called perching.

Wool cloth is also strengthened by the use of ply yarns. A hard-twisted two-ply yarn may be regarded as an assurance of durability. Tightly twisted single yarns also make a strong fabric.

The structure of the cloth should be examined to determine whether it has been weakened by excessive napping.

*Crease Resistance.* Because wool fiber has a high degree of elasticity, wool fabric wrinkles less than any other; wrinkles disappear when the cloth is steamed. Good wool is very soft and resilient; poor wool is harsh. When buying wool fabrics, grasp a handful of the cloth to determine its quality. If the cloth retains the wrinkles and feels inelastic, this may indicate a mixture with cotton or an inferior grade of reused wool.

*Heat Conductivity.* As wool fibers are nonconductors of heat, they



Sources of fine hair fiber are the camel (top left), the llama, the alpaca (center left), the vicuna, and the Cashmere goat.

### DIFFERENCES BETWEEN WOOLEN AND WORSTED FABRICS

| | Woolen Fabrics | Worsted Fabrics |
|---|---|---|
| FIBER | Short, curly fibers | Long, straight fibers |
| YARN | Carded only; slack twist; weaker yarns | Carded and combed; tightly twisted; greater tensile strength; generally yarn dyed |
| WEAVE | Indistinct pattern; usually plain weave, sometimes twill; cloth count generally less than worsteds | Distinct pattern; chiefly twill weave, infrequently plain weave; more closely woven than woolens |
| FINISHING | Soft finish; fulling, flocking, napping, steaming; as napping can conceal quality of construction, woolens are easily adulterated | Hard finish; singed, steamed; unfinished worsteds are napped; adulteration more difficult as fillers would be easily discernible |
| APPEARANCE AND TOUCH | Soft, fuzzy, thick | Flat, rough, harsh |
| CHARACTERISTICS | Warmer than worsteds; not so durable; nap acts as a protective agent against shine; soft surface catches and holds dirt; stains easily removed | Wrinkle less than woolens; more durable; hold creases and shape; become shiny with use; feel harsh when next to skin; more resistant to dust |
| USES | Generally less expensive than worsteds if poorer yarns are used; desirable for sportswear, jackets, sweaters, skirts, blankets, winter use | Costlier yarns; appropriate for tailored and dressy wear; spring and summer coats and suits, tropical suits; good for business wear |
| TYPICAL FABRICS | Tweed, homespun, flannel, broadcloth, shetland, cassimere | Gabardine, whipcord, worsted cheviot, serge, tropical worsted, Bedford cord |

permit the body to retain a temperature close to the 98.6 degrees that is required for perfect health. Thus, wool garments are excellent for winter clothing; they are also protective on damp days throughout the year. Lightweight wool of sheer construction may be worn in the summer for its thermostatic quality.

*Absorbency.* Wool fabric absorbs a great deal of moisture without feeling damp; it dries slowly. This makes it most suitable for bathing apparel.

*Cleanliness and Washability.* Dirt tends to adhere to wool fabric. Unless thoroughly cleaned, wool retains odors. Consequently, wool requires frequent dry cleaning or washing, if the fabric is washable.

Extreme care is required in laundering. Wool is softened by moisture and heat, and shrinking and felting occur when the fabric is washed.

*Shrinkage.* Shrinkage is greater in woolens than in worsteds, but all fabrics made of wool are subject to shrinkage; they will shrink less if dry-cleaned. "Chlorinated wools" have been subjected to good preshrinkage, but the strength of the fabric is diminished.

*Fastness of Color.* Because of their high affinity for dyes, wool fabrics dye well and evenly. The use of chrome dyes assures fastness of color.

*Resistance to Mildew and Moths.* Wool is not ordinarily susceptible to mildew; but if left in a damp condition, mildew develops. Wool fabrics are especially vulnerable to moths.

## Hair Fibers: Warmth without Weight

Hair fibers that have the qualities of wool are obtained from certain kinds of animals throughout the world. The hair of these animals has been so adapted by nature for the climate in which they live that the cloth produced from the fiber gives warmth without weight. Some of these animals are used primarily as burden carriers; others are bred for their fleeces, which produce the most expensive fibers in the textile industry.

These hair fibers are used alone or are combined with sheep's wool for construction into fabrics whose cost varies according to the amount and quality of the blend. The consumer must be careful to analyze descriptions of certain of these blends. Parts of the names of rare animals are sometimes used to convey false or nonexistent values to mixtures of cotton and wool that contain such insignificant quantities of the lowest grade of hair fibers that they could not possibly add quality to the fabrics.

**Camel's Hair.** Camel's hair is a fine hair that is known to the American consumer chiefly in the form of high-quality coat fabrics. This textile fiber is obtained from the Bactrian camel, which is native to all parts of Asia. The climate of the desert countries, where the camel is used as a burden carrier and as a means of transportation, is exceedingly hot during the day and extremely cold at night. This constant change has produced a protective hair covering that is a nonconductor of both heat and cold; it is also naturally water-repellent.

In the spring, the year's growth of hair, which hangs from the camel in matted strands and tufts, falls off in clumps in order to make room for the new growth. Masses of hair that are shed throughout the year are also accumulated. The camel is sometimes plucked to obtain the down or underhair.

Camel's-hair fabrics are ideal for comfort, particularly when used for overcoating, as they are especially warm but light in weight. Camel's hair is characterized by strength, luster, and smoothness. The best quality is expensive when used alone. It is often mixed with wool, thus raising the quality of the wool fabric by adding the fine qualities of camel's hair. The price of a mixed cloth is naturally much less than that of a fabric that is 100 per cent camel's hair.

In the textile industry, camel's hair is divided into three grades. Grade 1 is the soft and silky light-tan underhair found close to the skin of the camel. This is short staple or noil but is the choicest quality. Until recent years, it was the only true camel's hair used in the manufacture of apparel.

In wool, noils represent the less valuable short staple; but in the hair fibers, the short fibers are the prized product and are the only ones used in high-grade hair fabrics.

Grade 2 is the intermediate growth, consisting partly of short hairs and partly of coarse outer hairs. Grade 3 consists entirely of coarse outer hairs, varying in color from brownish black to reddish brown. This grade has no value for apparel manufacture; it is suitable only for cordage and for low-quality rugs.

**Mohair.** Mohair is the hair of the Angora goat, which is native to the province of Angora, Turkey. This species of goat is now raised to a considerable extent in the United States, principally in Oregon, California, and Texas. Some of the domestic mohair, particularly that obtained from Texas, is of excellent quality.

Imported mohair is of long staple, 9 to 12 inches long, and represents a full year's growth. The domestic goat is shorn twice a year, yielding a shorter staple, from 8 to 10 inches. Imported mohair can be spun to a fineness of 60s in yarn count. The highest count possible for domestic fiber is 40s. The domestic fiber has a great amount of coarse, stiff hair, known as *kemp,* which does not process readily or allow thorough penetration of dye.

Mohair is a smooth, strong, and resilient fiber. It does not attract or hold dirt particles. It absorbs dye evenly and permanently, and its fine luster permits unusual decorative effects. Mohair fiber is more uniform in diameter than wool fiber. Under the microscope, it shows almost no serrations; its indistinct scales do not project from the shaft as is characteristic of wool fiber. Therefore, mohair does not shrink or felt as readily as wool.

When mohair is used in pile fabrics, the naturally strong fiber combined with the strength of the pile weave makes an especially durable and serviceable fabric. Mohair fabrics are wrinkle-resistant and do not mat readily because of the natural resiliency of the fiber. The fabric can be made mothproof. Mohair is used in quality floor coverings and in the better grades of upholstery and drapery materials.

**Cashmere.** The Cashmere goat is native to the Himalaya region of China and India. The fleece of this goat has long, straight, coarse outer hair of little value; but the small quantity of underhair, or down, is made into luxuriously soft wool yarns with a characteristic highly napped finish. Cashmere first became familiar in the beautiful soft, light cashmere shawls for which India has been famous. This fine cashmere wool is not sheared from the goat but is obtained by frequent combings during the shedding season.

In the textile industry, the name cashmere is also used to designate a soft wool yarn that resembles the unusually fine fiber of the Cashmere goat.

The microscope reveals that cashmere is a much finer fiber than mohair or any wool fiber obtained from sheep. The scales are less distinct and are farther apart; the fiber appears to be made of sections placed within each other.

**Llama.** The llama is allied to the camel in species, having many of the characteristics of that animal, but being about one-third its size. The llama is the traditional burden carrier in the highest parts of the Andes Mountains in South America and therefore has not been bred for its fleece. Its hair fiber is generally coarse and brownish in color and is valued because it may be mixed with the hair of the alpaca, an animal of the same species that is raised for its fleece alone. Some noils are obtained from the undercoat of the llama, also.

When llama is part of a blend of fibers, it gives exquisite natural colors that can be found in few fabrics. Llama mixtures have a characteristic high insulative property with little weight and are used for high-quality coat fabrics, as they embody the essential qualities of wrinkle resistance, fastness of color, and extreme durability.

**Alpaca.** In the higher regions of the Andes, 14,000 feet above sea level, is found another fleece bearer, the alpaca, a domesticated goatlike animal that yields a fiber valued for its silky beauty as well as for its strength. The alpaca is related to the camel and the llama but is bred only for its luxurious fleece.

The hair of the alpaca is about 300 per cent stronger than ordinary sheep's wool. It is also water-repellent and has a high insulative quality. The staple is relatively long, ranging from 6 to 11 inches; yet it is as delicate, soft, and lustrous as the finest silk.

Alpaca consists of two varieties of fiber: soft, wool-like hair; and stiff beard, or outer hair. Of the many colors obtainable, ranging from white to brown and black, the reddish brown variety is considered the most valuable.

A more highly selected type of alpaca is the *suri*—a superbreed just as the Merino is the highest type of sheep. The fiber of the suri is sought by manufacturers of outer apparel because the staple is longer, silkier, and finer, and has curl throughout its length. A crossbreed, with the alpaca as sire and the llama as dam, produces the *misti.* Another crossbreed, the *huarizo,* is the result of breeding a llama sire and an alpaca dam.

**Vicuna.** The rare animal whose fiber makes the world's most costly and most exquisite cloth, surpassing all others in fineness and beauty, is found in an almost inaccessible area of the Andes Mountains, at altitudes between 16,000 and 19,000 feet.

The vicuna, one of the wildest of animals, is less than 3 feet high and weighs 75 to 100 pounds. A single animal yields only ¼ pound of fine hair; thus, forty animals are required to provide enough hair for the average coat. Formerly, the animals were killed to obtain the hair; but, in order to preserve the species, the vicuna is now under the protection of the Peruvian and Bolivian governments. Attempts to domesticate this animal have not been very successful but are still being made in Peru.

The fiber of the vicuna is the softest and most delicate of the known animal fibers, yet it is extremely strong and resilient, and has a marked degree of elasticity and surface cohesion. It is used in costly suitings and overcoat fabrics.

## Glossary of Wool Fabrics [1]

**Alpaca.** The lower grades of alpaca were originally used as linings and the better grades for fine dress goods. The fabrics currently being sold as alpaca merely resemble an alpaca fabric in finish; the use of the term for such fabrics is incorrect.

**Astrakhan.** A rough fabric with a closely curled face resembling that of the Astrakhan lamb's pelt. Often made with cotton warp or cotton back.

**Batiste (wool).** A lightweight wool cloth in a plain weave similar to plain cambric. Wool batiste should be all wool unless otherwise described.

**Bedford cord.** A vertically ribbed cloth of substantial construction used where severe wear is encountered. The rib is pronounced and runs in the same direction as the warp. Originally an all-wool cloth, it is now also made of other fibers. The term describes the weave rather than the material.

**Bengaline.** A thin fabric made generally of silk and wool, usually with a relatively inconspicuous rib running at right angles to the warp. The name does not denote any particular fiber blend.

**Bolivia.** A soft plushlike fabric of wool, usually containing some special wool fiber, such as alpaca or mohair. The term is properly applied only to an all-wool product, closely woven and of fine stock.

**Bouclé.** A fabric woven from curled or specially twisted yarn in such a way as to produce small loops on the surface, giving a kinky appearance. The curled nap does not cover the entire surface but occurs at intervals, distinguishing it from astrakhan. This type of fabric is usually made in coating weights but is also made in lighter weights for use as dress goods.

**Broadcloth.** A fine wool cloth openly woven and then fulled to achieve uniform texture. The surface is then napped, closely sheared, and polished. The term originally was applied only to wool fabrics, but for a number of years it has also been applied to a cotton cloth used principally for men's shirtings. Not only is the fiber content of these fabrics wholly dissimilar but also the construction, finish, and use, so that they cannot be confused.

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[1] Courtesy of Associated Wool Industries.

**Camel's hair.** In undyed form, camel's hair is light tan. Fabrics that merely have this distinctive color cannot be correctly called camel's hair. The best grade is very expensive, and even then camel's hair is sometimes mixed with sheep's wool or other fibers.

**Candlewick.** A soft woolen dress material made in imitation of the candlewick bedspread, with tufted patterns similarly applied.

**Cashmere.** A real cashmere fabric is woven only from the hair of the Cashmere goat. It is of fine close twill weave and extremely soft. The total amount of cashmere wool available is strictly limited.

**Cassimere** (not to be confused with cashmere). Cassimere is a woolen cloth closely woven with a plain twill weave, and fulled. Most woolen cloths that do not fall into some other classification are referred to as cassimeres.

**Challis.** A lightweight sheer fabric of all wool or of silk and wool. Sometimes made with a woven pattern but more often printed with designs after weaving. The designs are commonly of the type found in silk goods. Challis is made of fine yarn; it is very thin, light in weight, and soft and pliable.

**Cheviot.** A rough, somewhat harsh woolen fabric, but woven from finer yarns than are used in typical tweeds. Usually in either plain colors or herringbones but may be made in other fancy patterns. Woven from woolen yarns except for the more expensive cheviots made from worsted yarns, generally in high colors, and referred to as worsted cheviots.

**Chinchilla.** A thick, heavily napped cloth with a close curled surface in imitation of chinchilla fur. The tufts are close together, covering the entire surface. Generally dyed in the piece in solid colors. Used for women's and children's coats and hats.

**Covert.** Twilled cloth made from highly twisted yarns, usually of two colors, which gives the fabric a speckled appearance. Closely woven with a fine, smooth face. Used largely for men's topcoats and women's coats or mannish tailored suits.

**Crepe (wool).** Wool crepe is a lightweight worsted fabric with a more or less crinkly appearance, obtained by using warp yarns that are tightly twisted in alternate directions. The term is often applied to lightweight worsted fabrics for women's wear that have little or no crepe surface.

**Doeskin.** A very close and compact wool cloth with exceptionally smooth face. The weave is similar to a sateen, but the smooth finish of the cloth generally obliterates any trace of the weave on the face.

**Flannel.** A fulled and napped woven fabric, made generally of woolen yarn but sometimes with worsted yarn used in the warp or filling. Usually woven with a twill weave, which may be obscured by the nap. Distinguished for its softness. Used for bathrobes, skirts, men's suits and trousers. Cotton flannel or flannelette is not dissimilar in appearance.

**Fleece.** A wool fabric with a deep, soft nap. This term may be properly applied to flat woven or knit woolen fabrics as well as to fabrics woven on the pile principle. The long nap or pile, as the case may be, provides many air spaces, resulting in a fabric with high insulative properties.

**Gabardine.** A firm, hard-finished worsted fabric in the twill weave with a fine diagonal wale.

**Homespun.** A coarse and loosely woven woolen material made to simulate homemade cloth—in effect, a coarse, rough tweed. Yarn is usually heavy and contains coarse wool fiber unevenly spun.

**Hopsacking.** A rough open-weave woolen fabric made of coarse yarn, usually in a basket weave. Used for novelty effects.

**Jersey.** An elastic knitted fabric made from either woolen or worsted yarn. The rib that results from the knitting is clearly discernible on one side of the fabric.

**Kersey.** A medium-weight woolen cloth, well fulled in the finishing, with a napped and closely sheared surface that obscures the weave. Used extensively for military and civil uniforms.

**Mackinaw.** A heavy woolen fabric without nap but heavily fulled or felted, with the result that no weave is apparent on the surface. In general construction, the same as melton except that the latter is usually made in plain colors, whereas mackinaw cloth is commonly woven with large distinctive plaids or color effects. Usually made of the coarser wools.

**Melton.** A well-fulled or felted overcoating fabric with smooth finish and no nap. Generally in plain colors. The coarser meltons are similar to mackinaw cloth, but are sometimes made of fine, soft wools to produce a smooth coating fabric with a finish similar to that of broadcloth.

**Mohair.** Yarns and fabrics of mohair are bright and lustrous. Warp yarns of cotton or worsted are generally employed in the manufacture of flat mohair fabrics. The mohair pile fabrics used in automobiles and for upholstery usually have the pile introduced as a warp, but in such a fashion that the special system of threads is not subjected to severe tension.

**Nun's veiling.** A fine, lightweight plain-weave woolen fabric, very soft and thin, originally for veils but now used for women's and children's dresses. Plain colors.

**Plaid back.** A type of construction used in overcoatings. The face of the fabric may be finished like melton, fleece, or similar cloths. The back is a fancy or tartan plaid.

**Poplin (wool).** Originally a fabric having a silk warp and a filling that consisted of a wool yarn heavier than the silk, thus producing a ribbed surface something like a rep. Now made of different fibers or combinations thereof.

**Rabbit's hair.** Rabbit's hair is used in combination with other fibers. It is soft and lustrous. In the better fabrics, enough hair may be present to justify the use of the term.

**Ratiné.** A rough, pebbly woolen fabric the surface interest of which is obtained by the use of novelty yarns with a fancy twist.

**Saxony.** A term applied to certain flannels and to smooth woolen fabrics made from fine wools similar in nature to Saxony wools.

**Serge.** A fabric with a diagonal twill and a smooth finish. The twill is visible both on the surface and on the back. Dark blue is the color most commonly used, but other plain colors are made for certain purposes.

**Sharkskin (wool).** A term descriptively applied to wool fabrics woven in a 2 and 2 right-hand twill, with a 1 and 1 color arrangement of yarns in the warp and filling. This combination of weave and color results in color lines running diagonally to the left, opposed to the direction of the twill lines, and a distinctly sleek appearance and feel that suggests the texture of the skin of the shark. Modifications of this design are often loosely designated as sharkskin.

**Sheers (wool).** A general classification under which may be grouped all thin lightweight women's-wear fabrics. Usually woven from worsted yarns, although some woolen fabrics are sufficiently thin to be classified as sheers.

**Shetland.** The term is now applied to fabrics made of wool with the characteristics of Shetland Islands wool. Shetlands are extremely soft. The herringbone weave is common, but the name describes the type of wool and not the weave.

**Snow cloth.** A term for fabrics designed for outdoor winter use. It may be applied to meltons, kerseys, heavy flannels, and similar fabrics.

It is often used to indicate that these fabrics have been given a water-repellent finish.

**Suede (wool).** A fine, soft fabric with closely clipped nap made to imitate suede leather.

**Tropical weights.** Lightweight suitings of woolen or worsted, usually the latter, used for men's and less frequently for women's summer suits. The weave should be firm but open, as the fabric is especially designed for hot-weather wear.

**Tweed.** A term broadly applied to the sturdier types of fabrics made of the coarser grades of wool. Tweed fabrics originally derived their interest from the color effects obtained by mixing stock-dyed wools. More recently the term includes monotones, which derive their interest from weave effects. The most popular weaves for tweeds are the plain, the twill, and variations of the latter.

**Velour (wool).** A smooth, sleek fabric with a closely cut pile face. The upright pile, which yields in any direction, gives the fabric an exceedingly smooth feel.

**Vicuna.** Short, soft, exceedingly fine hair fiber, very valuable because of the limited supply. It is rarely used by itself, although a few vicuna coats are manufactured each year. Sometimes mixed with wool to produce special soft coating fabrics. The term and certain derived and coined names have been much misused.

**Whipcord.** A sturdy wool fabric with a pronounced diagonal wale. It is closely woven and smooth-finished; principally used for riding habits and other garments subjected to hard wear. In the heavier weights used as upholstery.

*Test yourself on this chapter by answering these questions:*

1. What are the advantages of wool fabrics?
2. Name the classification of fleeces according to quality.
3. What countries supply the world with wool?
4. Explain the Government classifications of wool.
5. What qualities are found in lamb's wool?
6. How are grease and dirt removed from the fleece? What by-product is obtained from the grease?
7. Name six differences between woolens and worsteds.
8. Name three woolen fabrics and three worsted fabrics.
9. What are unfinished worsteds?
10. How would you judge quality wool fabrics?

11. What finishing processes are used for woolens?

12. Which finishing processes are used for worsteds? Why?

13. How do worsteds compare with woolens as to appearance and touch?

14. Which type of wool fabric is warmer? Why? Which stronger? Why? Which higher in price? Why?

15. Discuss the qualities of the hair fibers, telling their sources and how they are used.

## Suggested Readings

Dooley, W. H., *Textiles,* Chapters 2, 3, 4, 9, 14.
Dyer, E., *Textile Fabrics,* Chapter 7.
Eavenson & Levering Co., *Wool Handling.*
Hess, K. P., *Textile Fibers and Their Use,* Chapter 2, Section 2.
Matthews, J. M., *The Textile Fibers,* Chapters 3, 7, 8, 20, 23.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 6.
Nystrom, P. H., *Textiles,* Chapters 10, 11, 12, 13, 15.
Small, C. P., *How to Know Textiles,* Chapters 14, 16.
Von Bergen, W., and Mauersberger, H. R., *American Wool Handbook.*
Wingate, I. B., *Textile Fabrics,* Chapter 8.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 7.

## CHAPTER XI

# SILK: SOFT, STRONG, AND LUXURIOUS

The possibility of making cloth from the filament that the silkworm spins into a cocoon was first discovered in China about 2600 B.C. The Chinese cultivated the silkworm and developed a silk industry, endeavoring to keep the source of the raw material a secret. They succeeded for many years, but eventually Chinese emigrants introduced the silkworm into Japan in A.D. 300.

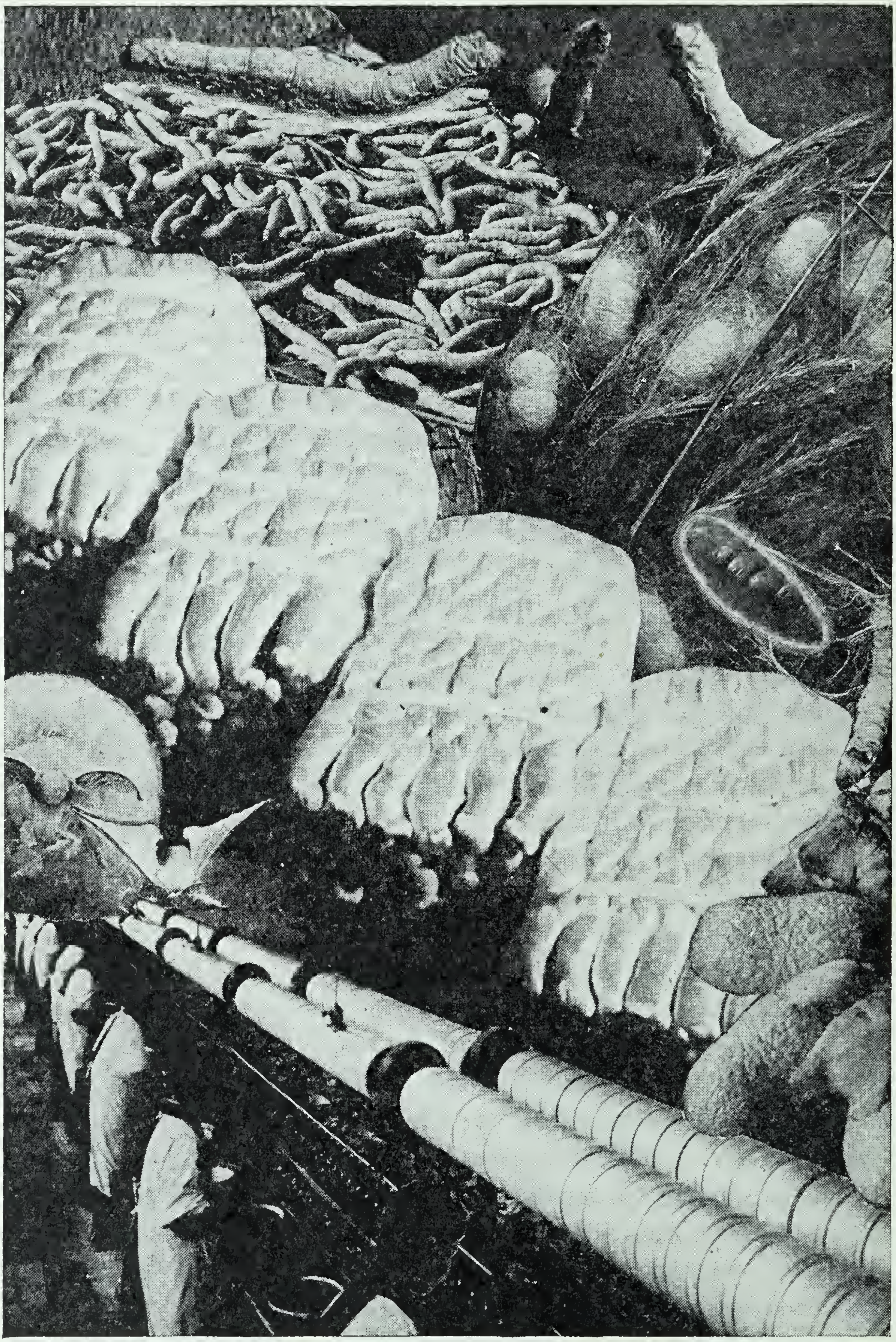
Eggs of the silk moth were smuggled out of China into southeastern Europe in A.D. 550. Spain began to produce silk in the eighth century, and Italy in the twelfth. It was the sixteenth century before the industry developed in France and England.

After America was settled, attempts were made to cultivate the silkworm in the United States. None of these attempts succeeded, not because it was impossible to feed and raise the silkworms, but because of higher labor and production costs in this country. The silk industry is of importance in the United States even though raw silk is not cultivated in this country.

The United States has been the greatest importer and consumer of silk; that part of the industry that manufactured raw silk into fabrics has closely touched the lives of American consumers. The possession of silk fabrics has always represented an ideal of luxury to Americans, perhaps more than to the inhabitants of other countries. Silk will probably always be prized by the consumer even though man-made fibers now have qualities that were formerly possessed only by silk.

**Silk-producing Countries.** When farmers in the Asiatic countries first raised silkworms, the many diseased worms and defective cocoons resulted in poor grades of finished goods. The farmers were raising silkworms only as an additional means of support.

Japan was the first country producing silk in large quantities to use scientific methods in cultivating the silkworm on the farms as well as in the factories. Japan has therefore always ranked highest in the produc-



Important stages of sericulture are shown here: development of the moth through the stages of egg, silkworm, and chrysalis, reeling of cocoons in the factory, and books of silk ready for shipping.

tion of fine silks, although satisfactory types are made in other silk-producing countries—China, Italy, Spain, France, Austria, Iran, Turkey, Greece, Syria, Bulgaria, and Brazil.

The cultivation of the silkworm requires extreme care and close supervision, and the reeling of the filament from the cocoons can be undertaken only by skilled operators whose training is the result of many generations of experience.

**Cultivation of Silk Cocoons.** Since the discovery, so many years ago, that the fiber, or filament, that composes the cocoon of the silkworm can be unwound and constructed into a beautiful and durable cloth, silkworms have been bred for the sole purpose of producing raw silk. The production of cocoons for their filament is called *sericulture.* The cocoon of the silkworm is the second stage of development of the life cycle of the *Bombyx mori*, a species of moth. Experiments have proved that this moth produces the finest quality of raw silk.

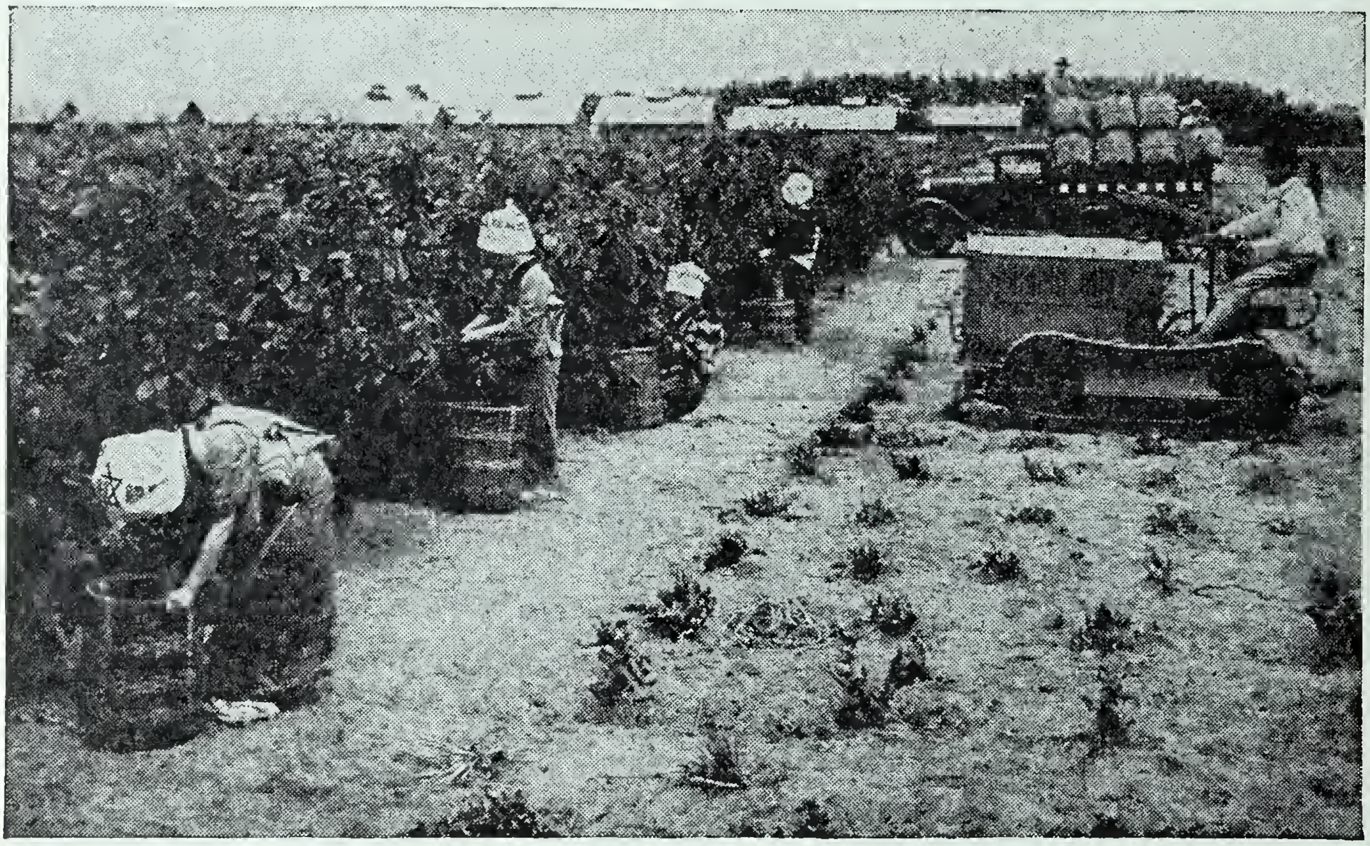
Japanese silkworm farmers carrying cocoons to factory markets.

In sericulture, all four stages of the life cycle of this moth are important, because some of the better cocoons must be set aside to permit full development, thus supplying eggs for another hatching. Under scientific breeding, silkworms may be hatched three times a year;

under natural conditions, breeding occurs only once a year. The life cycle is:

1. The *egg,* which develops into the larva or caterpillar; that is, the *silkworm.*
2. The *silkworm,* which spins its cocoon for protection, to permit development into the pupa or *chrysalis.*
3. The *chrysalis,* which emerges from the cocoon as the *moth.*
4. The *moth,* of which the female lays *eggs,* so continuing the life cycle.

The female moth lays from 350 to 400 eggs and dies about three days later. Each healthy egg hatches into a grub, or larva, about 1/8 inch long. The larva requires careful nurturing for approximately twenty to thirty-two days. During this period the tiny worm has a voracious appetite. It is fed five times a day on chopped mulberry leaves. After four changes of skin, or moltings, the worm reaches full growth in the form of a smooth grayish-white caterpillar, about 3½ inches long. Of importance to the silk industry are the two small openings under the jaws, which are called *spinnerets.*



Picking mulberry leaves, the food of the silkworm.

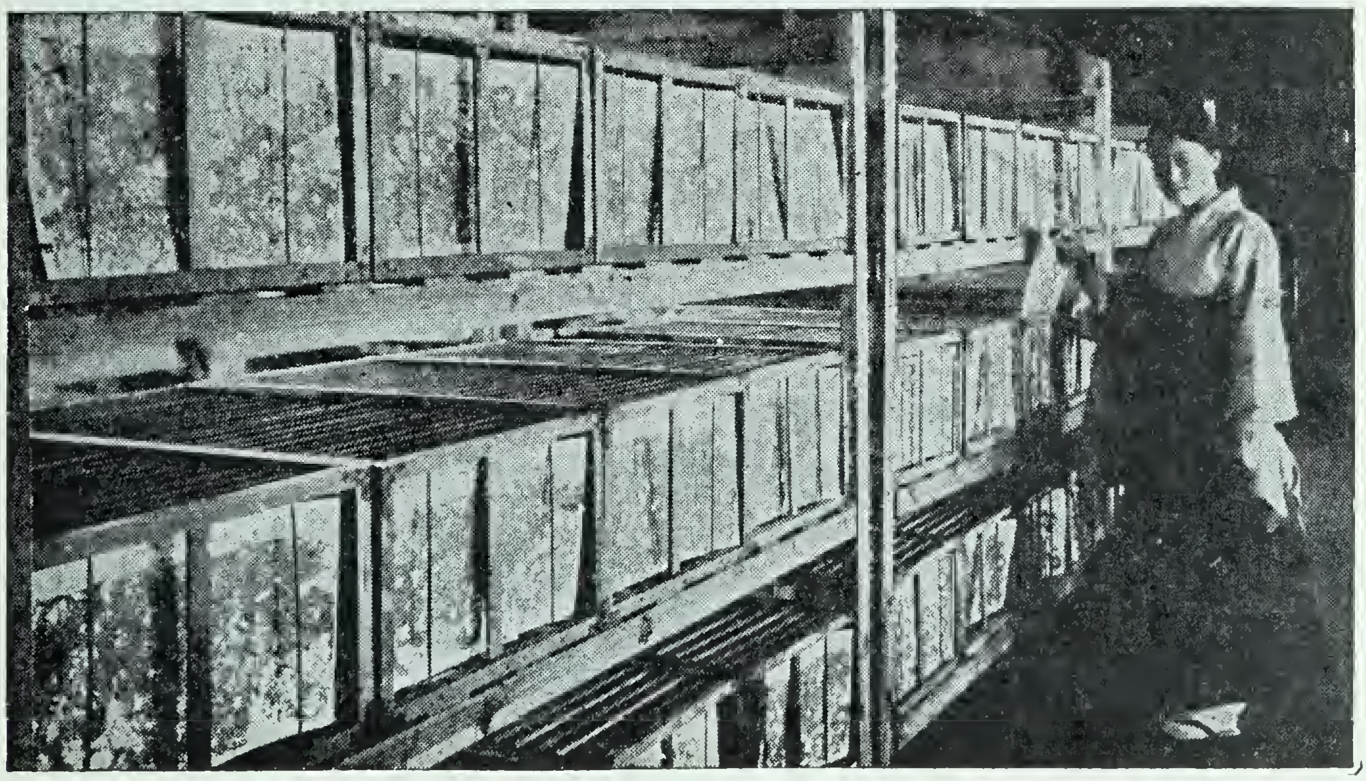
When the silkworm reaches maturity, its interest in food ceases;

it shrinks somewhat in size and acquires a pinkish hue, becoming nearly transparent. A constant restless rearing movement of the head indicates that the worm is ready to spin its cocoon. Clusters of twigs or straw are provided for this purpose.

The silkworm begins to secrete a proteinlike substance through its spinnerets, and with a bending motion the filament is spun around the worm in the form of the figure eight. The silkworm is hidden

*Left:* Cocoons are being picked from nests of twigs that were originally provided to aid the silkworms in their spinning.

*Below:* When silkworms are raised in factories, the eggs are stored on cards, awaiting hatching.



from view within twenty-four hours; in three days the cocoon is completed. It is about the size and shape of a peanut shell. The filament is in the form of a double strand of fibroin, which is held together by a gummy substance called *sericin,* or silk gum. The liquid substance hardens immediately on exposure to the air.

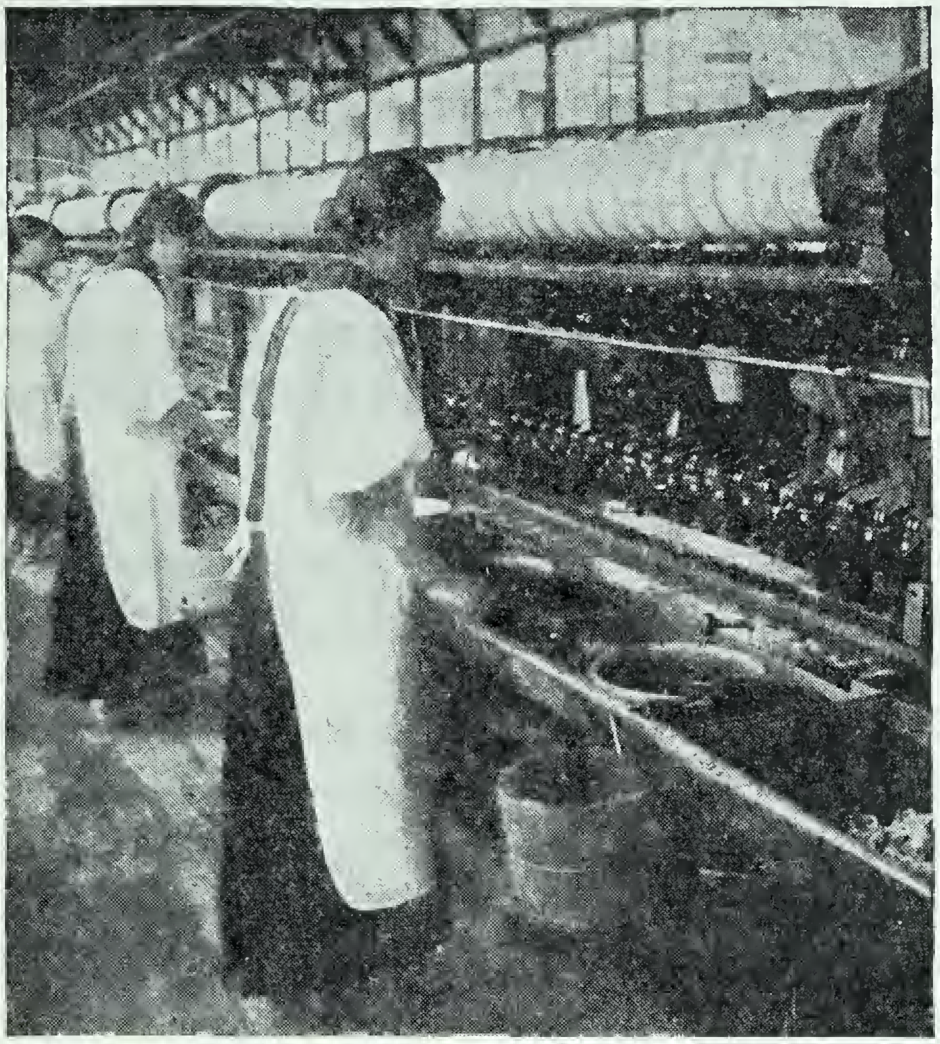
If left undisturbed, the chrysalis inside the cocoon develops into a moth within two weeks. In order to emerge, the moth must break through the top of the cocoon by excreting an alkaline liquid that dissolves the filament. As this cutting through damages the cocoon so that the filament cannot be unwound in one long thread, the life cycle is terminated at this point. The cocoons are heated to suffocate the chrysalis, but the delicate silk filament is not harmed.

*Sorting the Cocoons.* The cocoons that are raised by silk farmers are delivered to a reeling factory called a *filature.* Some cocoons are scientifically bred in the factory. They must be sorted according to color, size, shape, and texture, as all these factors affect the final quality of the silk. Cocoons may range from white or yellow to grayish, depending on the source and the type of food consumed during the worm stage. Cocoons from China are white; Japanese cocoons are creamy white and yellow; Italian are yellow.

*Softening the Sericin.* After the cocoons have been sorted, they are put through a series of hot and cold immersions, as the sericin must be softened to permit the unwinding of the filament in one continuous thread. Raw silk consists of about 80 per cent fibroin and 20 per cent sericin. Only about 1 per cent of the sericin is removed because this silk gum is a needed protection during the further handling of the delicate filament.

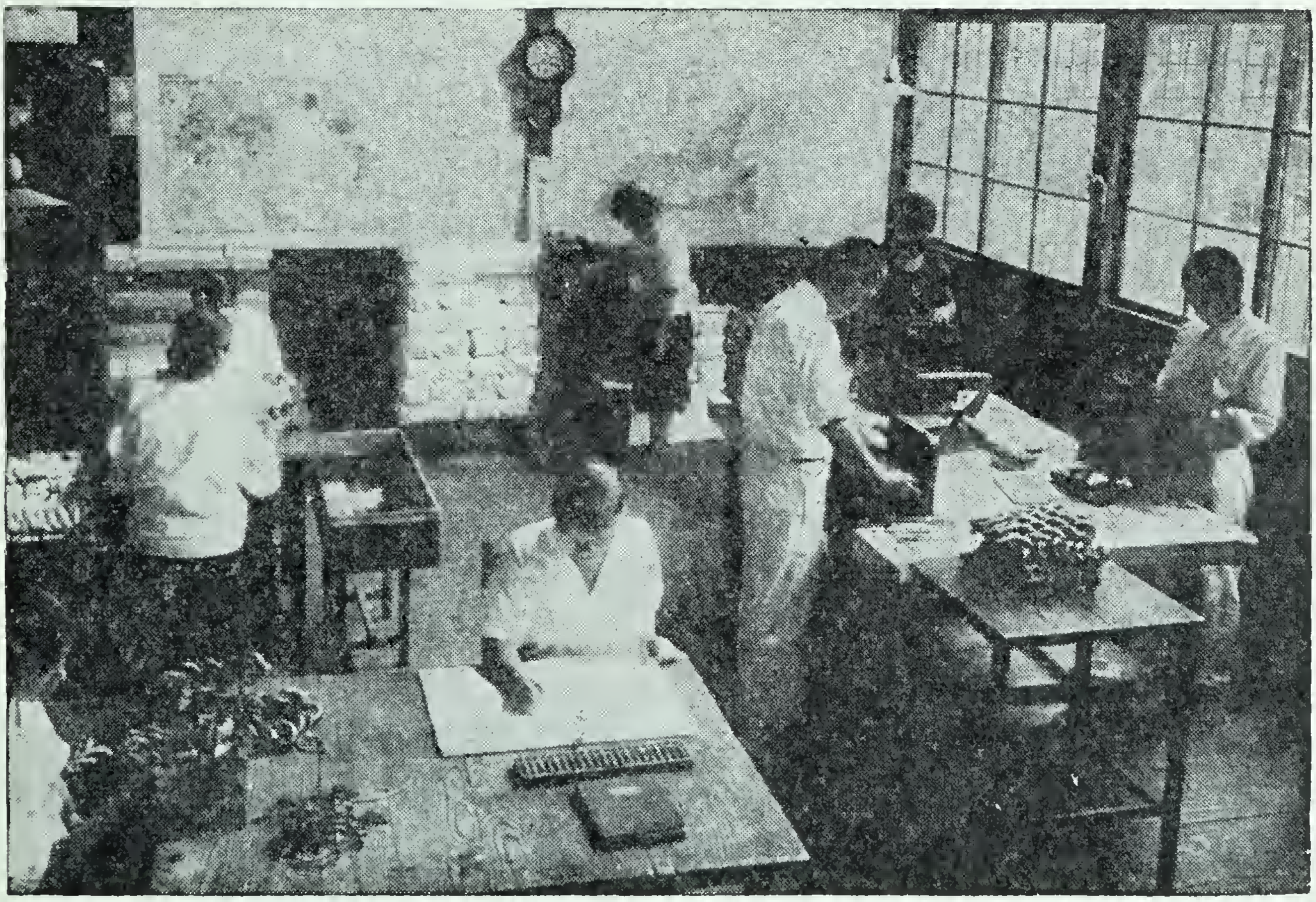
*Reeling the Filament.* The process of unwinding the filament from the cocoons is called *reeling.* The care and the skill used in the reeling operation prevent defects in the raw silk. Several cocoons are reeled together, as the filament of a single cocoon is too fine for commercial use; five or six strands are necessary to produce a workable diameter of raw silk thread.

The cocoons float in water, bobbing up and down, as the filaments are drawn upward through porcelain eyelets and are rapidly wound on wheels or drums while the operator watches to detect flaws.



*Left:* Cocoons lie in a trough of water as skillful operators reel the filament on wheels (at top of machine). New filaments are attached and blended with the rapidly moving silk threads.

*Below:* Books of silk being made up and weighed, ready for shipping.



As the reeling of the filament from each cocoon nears completion, the operator attaches a new filament to the moving thread. Skilled operators have an uncanny ability to blend the filaments, always retaining the same diameter of the rapidly moving silk thread. The sericin acts as an adhesive; it aids in holding the several filaments together while they are combined to form the single thread. On old-style reeling machines, at high speed, an operator could handle five to seven threads; on the newest models it is possible to handle twenty-five threads.

The usable length of the reeled filament is from 1,000 to 2,000 feet, approximately one-quarter of a mile long. The remaining part of the filament is used as valuable raw material for the manufacture of spun silk.

**Reeled Silk.** The term *reeled silk* is applied to the raw silk strand that is formed by combining several filaments from separate cocoons. It is reeled into skeins, which are packed in small bundles called *books,* weighing 5 to 10 pounds. These books are put into bales, ranging in weight from 135 to 145 pounds. In this form, the raw silk is shipped to all parts of the world.

*Silk Throwing.* Reeled silk is transformed into silk yarn—also called silk thread—by a process known as *throwing.* The term is derived from the Anglo-Saxon word "thrawn," meaning "to twist." Persons who are engaged in this work are called *throwsters.* Silk throwing is analogous to the spinning process that manufactures cotton, linen, or wool fibers into yarn. Unlike these other fibers, the manufacture of silk yarn does not include carding, combing, and drawing out, the usual preparatory processes for producing a continuous yarn.

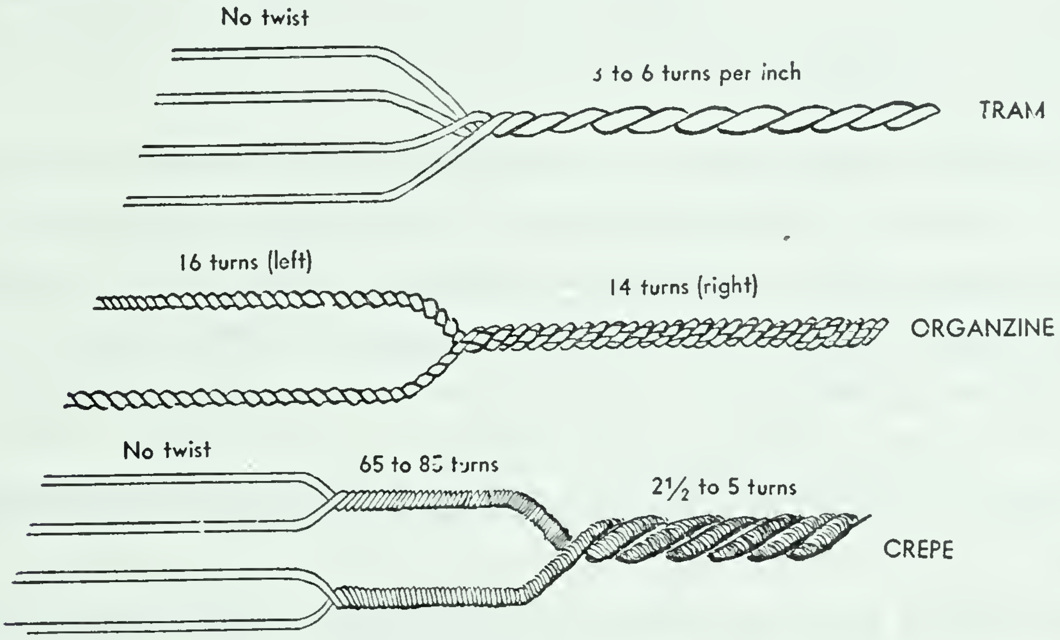
The raw silk skeins are sorted according to size, color, and length or quantity, then soaked in warm water with soap or oil. This softening of the sericin aids in handling the thread. After mechanical drying, the skeins are placed on light reels, from which the silk is wound on bobbins.

During this winding operation, single strands may be given any desired amount of twist. If two or more yarns are to be doubled, they are twisted again in the same direction or in a reverse direction, depending on the kind of thread to be made. To equalize the diameter, the thread is run through rollers. The thread is then inspected and packaged ready for shipment to manufacturers for construction into cloth.

**Kinds of Thrown Silk Threads.** The most important kinds of silk yarns or threads used in manufacturing silk goods are singles, tram, crepe, and organzine.

1. *Singles.* Singles may consist of three to eight or more doubled strands that have been given a varying amount of twist in one direction, depending on the size and strength desired. Singles may be used for warp or filling according to the amount of twist. They are used in sheer fabrics.

2. *Tram.* Tram is used only as a filling yarn. Usually two or three untwisted strands of reeled silk are combined with only a slight twist, such as two or three turns to the inch. The number of turns may be increased in especially heavy silk. Tram is rarely twisted more than six turns to the inch, except in such fabrics as radium and taffeta, which use a special hard-twisted tram of about thirty turns to the inch.



Kinds of thrown silk threads: tram, organzine, crepe.

3. *Crepe Twist.* Silk yarns for crepe fabrics require a great amount of twist, which may run as high as one hundred turns to the inch. Today, crepe yarns usually comprise two to ten silk strands and have sixty-five to eighty-five turns to the inch. These yarns may be used for warp or filling.

4. *Organzine.* Only the highest-quality silk threads are made into

organzine yarns; such yarns are used only for the warp. Organzine yarns are always a plied construction. Two or more silk threads are twisted separately as singles, usually with sixteen turns to the inch; these threads are combined. The doubled thread is then twisted together in the opposite direction from the original twist, with fourteen turns to the inch. This makes what is called a 14/16 thread. An especially hard-twisted organzine (20/18 to 60/60) used for hosiery is called *grenadine* thread. It is also used for sheer silk fabrics, such as silk voile and grenadine.

**Yarn Count of Silk Threads.** The size or the yarn count of silk threads is based on a system of weight known as the *denier.* A denier represents a weight of 5 centigrams; that is, .05, or 1/20, gram. The standard length of a raw silk skein is 450 meters. A 450-meter skein weighing 1/20 gram contains a one-denier thread, which is an extremely fine thread.

The most common size of raw silk from Japan was 13/15 denier. This is as fine as a 350s cotton yarn. In the spring crop, a 13/15 denier requires four to five cocoons to a thread, whereas the summer and autumn crops require five to six cocoons to the thread. As each cocoon comprises two filaments, a 13/15 denier may contain eight to ten or twelve to fourteen filaments, depending on the season. The greater the number of cocoons used, the coarser the thread and the higher the denier.

In order to find the denier of 450 meters of silk thread weighing 70 centigrams (the usual weight of skeins from Japan), divide 70 by .05, or 1/20. The result is 14. The denier is expressed as 13/15 in order to allow for variation in the diameter of the thread.

In the laboratory, the denier size of a silk thread is obtained by a different method of figuring. The weight of a 450-meter skein is multiplied by 20. This figure is used because 20 denier equals 1 gram, as 1 denier equals 1/20 gram. For example, if the 450-meter skein weighs 2.16 grams, multiplying this weight by 20 gives 43.2, which is expressed as a 42/44 denier in order to allow for variation.

**Degumming.** Thrown silk threads still contain some sericin, which must be removed in another soap bath in order to bring out the natural luster and the soft feel of the silk. As much as 25 per cent of the weight of the silk is lost by the degumming process.

Degumming may take place after the silk thread is thrown in order to prepare it for yarn dyeing, or it may be done in any finishing process after the cloth is woven. For example, the tightly twisted yarns used for crepe effects still contain sericin. A small amount of sericin is sometimes left in the yarn or in the fabric in order to give the finished product added strength or a dull finish. Ecru and souple are examples of silk fabrics from which sericin has been partially removed.

When all the gum has been removed, the silk fiber or fabric is a creamy-white color, beautifully lustrous and luxuriantly soft.

**Weighting.** The amount of weight that silk loses in the degumming process is an appreciable factor in manufacturing costs because the manufacturer buys silk by weight. As is customary in any business, the price of the finished product must offset this loss; therefore silk has always been an expensive fabric. The weighting of silk fabric with metallic substances in order to make up for the weight lost by degumming is an accepted practice in the silk industry. This procedure lowers the cost of silk to the consumer.

Weighted silk is less compactly woven than unweighted silk, and less silk is used in the construction of the cloth; in other words, weighting rather than compact construction gives firmness and body to the fabric.

Weighting is done in the dyeing process. To weight colored silks, stannic chloride is used, followed by treatment with sodium phosphate. Black silks are weighted with metallic mordants, such as iron salt and logwood.

A small amount of metallic weighting, correctly applied to a fabric that is well woven to hold the weighting, is not considered injurious. In addition to lowering the cost, it is claimed that weighting gives silk crispness, luster, and a firmer body and feel. When weighted silk is pleated, the crease is retained. Weighted silk, however, loses the natural elasticity of the silk fiber and is subject to deterioration when exposed to sunlight, perspiration, and dry cleaning. When the fabric is not properly constructed, threads shift. If the fabric is not woven sufficiently wide to allow for natural shrinkage, there is an unsatisfactory amount of shrinkage.

Taffeta is a commonly used fabric that is usually heavily weighted, because today there is little demand for pure-dye taffeta. Weighted taffeta is apt to crack and split at the places subjected to the strain of wear and when folded for a length of time. (Rayon taffeta does not contain any metallic weighting.)

Because the consumer cannot determine the percentage of weighting in a silk fabric, the Federal Trade Commission ruled in 1938 that weighted silk must be marked as such, and the percentage of weighting must be indicated on the label.

**Pure-Dye Silk.** As silk is weighted during the dyeing process, the term *pure-dye silk* indicates that weighting was not added at that time. According to the Federal Trade Commission rulings, pure-dye silk is defined as a fabric made exclusively of silk fibers containing *no metallic weighting whatsoever*; but the use of such water-soluble substances as starch, glue, sugar, or gelatin in the dyeing and finishing processes is allowed. Such foreign substances are limited to 10 per cent for white or colored silks and 15 per cent for black silks.

Well-constructed pure-dye silk requires a greater amount of silk thread than weighted silk because pure-dye silk is usually more compact. Thus it is generally superior, having the qualities of elasticity and durability because the natural elasticity of the silk fiber has not been lessened and its great natural strength has been retained.

**Spun Silk.** Short lengths of inferior silk filaments obtained from waste material are not used in producing reeled silk. After the short lengths have been carded and combed, they are spun together very much as cotton, linen, or wool yarns are spun. Spun-silk threads are soft, but they are less lustrous than reeled silk. Neither are they so strong or elastic. Spun-silk fabric tends to become fuzzy after wearing because the yarn is made of short staple.

The waste materials are obtained from: (1) pierced cocoons, which are the result of breeding moths; (2) imperfect cocoons; (3) machine waste left from reeling and throwing; (4) inner skin of cocoons left after reeling; (5) floss silk brushed from cocoons before reeling; (6) coarse fibroin from the beginning and end of each cocoon.

Spun silk is less expensive than reeled silk. Although spun silk possesses less strength and elasticity than reeled silk because of the shorter staple used, yet spun silk possesses all the general characteristics of reeled silk. Tub silk fabric, for example, is made of spun silk; yet it gives good service when the quality of the fiber is good. Spun silk is used for inexpensive grades of silk hosiery and pile fabrics; for dress trimmings, linings, elastic webbing, and sewing silk; for summer wash silks, for velvets, and for umbrella fabrics. Spun silk is also used for insulative materials.

*Yarn Count of Spun-Silk Threads.* The method of determining the size of spun-silk thread is similar to the method used for cotton yarn. In cotton, the term 2/60s signifies a two-ply yarn consisting of two single strands twisted together, each having a yarn count of 60.

In spun silk, a two-ply yarn is indicated by the figures 60s/2. Although this term appears to be only the reverse of the cotton term, it does not mean the same. In spun silk, 60s/2 means that two yarns with a separate yarn count of 120 have been doubled, producing a ply yarn with a new count of 60.

**Wild or Tussah Silk.** Wild species of silkworm live on oak leaves instead of on the mulberry leaves that form the food of the cultivated species. This coarser food produces an irregular and coarse filament, which is hard to bleach and hard to dye. The tannin in the oak leaves gives wild silk its tan color, and the silk is commonly woven with the naturally colored thread; it is rarely dyed except in solid shades.

Wild silk is less lustrous than cultivated silk as only a low percentage of sericin is removed in the degumming process. Wild-silk fabrics are durable and have a coarse, irregular surface. They are washable. Typical fabrics made from wild silk are rajah, shantung, tussah, and pongee.

The standard wild-silk thread differs from the standard reeled-silk thread in size as it is made from eighteen cocoons. It averages 32/34 denier. Generally, fabrics made from wild silk are less expensive than pure-dye silk fabrics.

**Finishing Processes.** The usual finishing processes that enhance the appearance of cloth and add to its serviceability are given to silk fabrics. Various special finishes may be used to make the cloth water-repellent. The most essential finishes for silk are:

*Singeing*—for smoothness.
*Bleaching*—very little required when silk is completely degummed.
*Stiffening*—for cheaper grades.
*Embossing*—if such patterns as moiré are desired.

*Calendering*—for enhancing luster.

*Steaming*—for pile weaves.

*Wringing and stretching*—softening the fiber and increasing the luster.

*Pressing*—removing wrinkles from finished cloth by passing it through heated rollers. The cloth is soaked in dilute acid to develop luster.

**Judging Silk Fabrics.** In spite of its high cost, silk has been one of the most popular fabrics because of its unique properties. Soft, supple, strong, and lighter in weight than any other natural fiber, silk is prized for its lightness with warmth, sheerness with strength, and delicacy with resiliency.

*Strength.* Silk is very durable when the fabric is well constructed. The fact that it is used for parachutes is the highest recommendation that could be given for the strength of its filament. The great length of the filament, which is a factor in strength, imparts smoothness to the fabric, as there are fewer fiber ends in silk fabrics than in any cloth made of natural fibers.

*Crease Resistance.* Silk fabrics retain their shape, resist wrinkling, and recover easily from creasing because of the natural elasticity of the fiber. This is particularly true of the fabrics made from pure-dye silk and from wild silk. Those that contain a large percentage of weighting or those made from the short-staple spun silk do not possess this degree of elasticity.

*Heat Conductivity.* Like wool, which is also a nonconductor of heat, silk is desirable for winter apparel. Even silk fabrics of sheer construction are comfortably warm when used for lingerie and linings. Silk is worn in the summer because of its smoothness and crease resistance, which help to retain a fresh appearance. The warmth-giving quality is materially lessened by weighting, as the metallic content causes the fabric to become a conductor of heat.

*Cleanliness and Washability.* Silk is a hygienic material because its smooth surface does not attract dirt, and any dirt that does gather is given up readily when silk is washed or dry-cleaned. All silks are easily spotted by water, but subsequent washing or dry cleaning restores the appearance of the fabric. Weighted silks are preferably dry-cleaned, but wild-silk and spun-silk fabrics may be washed. As perspiration deteriorates silk, undergarments should be washed immediately after each wearing.

*Shrinkage.* Because of the straightness of the filament, smooth-surfaced silk fabrics have only a normal shrinkage, which is easily restored by ironing. Crepe effects shrink considerably in washing, but careful ironing with a moderately hot iron will restore the fabric to its original size.

*Fastness of Color.* Dyed silk is colorfast under most conditions, but its resistance to light is unsatisfactory. The resistance of weighted silk is particularly poor. Therefore, silk is not recommended for window curtains. Pure-dye silks may be redyed by the consumer provided a suitable commercial dye is used and the directions on the container are carefully followed.

*Resistance to Mildew.* Silk will not mildew unless left for some time in a damp state, or under the extreme conditions of dampness found in tropical countries.

## Glossary of Silk Fabrics

**Bengaline.** A ribbed fabric having cotton or wool yarns for the filling and silk for the warp. Similar to poplin but having a heavier corded effect. Used for coats, suits, dresses.

**Broadcloth.** A fine, smooth, closely woven fabric in plain colors or in woven stripes; also known as silk shirting. It has a plain weave. Used for shirts and dresses.

**Brocade.** Most figured silk fabrics in a Jacquard weave are known as brocades. The pattern is raised above the general surface of the fabric. Used mainly for elaborate evening wear.

**Canton crepe.** Characterized by a heavy filling and a finer warp. Heavier than crepe de chine, having pronounced crinkle and greater durability. Used chiefly for dresses.

**Chiffon.** A transparent sheer fabric in a plain weave. Extremely light in weight but very strong. It usually has a soft finish. Used for evening dresses, lingerie, blouses, and handkerchiefs.

**China silk.** A very soft, extremely lightweight silk made in a plain weave, used chiefly for linings. Irregularities of threads, caused by the extreme lightness and softness of China silk, are characteristic of the fabric.

**Crepe.** Fabrics with a crinkled effect, produced either by the use of tightly twisted yarns or by the method of weaving.

**Crepe-back satin or satin crepe.** Satin weave with a crepe-twist filling. As the fabric is reversible, interesting effects can be obtained by contrasting the surfaces. Used for dresses, blouses, linings.

**Crepe de chine.** Soft but strong; lighter in weight than canton crepe. Has a fine crinkled effect produced by alternately twisted filling yarns. Popular for dresses, lingerie, blouses, and scarves.

**Crepe meteor.** Similar to georgette in construction on the reverse side. Satin construction on its face, thus showing more luster than any of the flat crepes. Light in weight, drapes well, has a soft feel and finish.

**Damask.** Reversible figured silk fabrics woven on the Jacquard loom. Pattern flatter than in brocade. Used for upholstery and draperies; the lighter weights, for dresses and lingerie.

**Ecru silk.** Thrown silk from which a small amount of sericin has been removed.

**Faille.** A silk fabric of the grosgrain type. In plain weave with flat ribs in the filling. Has good body and wears well if not too loosely constructed. Usually slightly lustrous finish. Used for dresses, coats, and handbags.

**Faille crepe.** Lighter weight than faille with creped filling. Used for dresses.

**Faille taffeta.** Stiff and crisp with a fine cross-ribbed appearance. Used for dresses and coats.

**Flat crepe.** Similar to crepe de chine but with a flatter surface.

**Foulard.** A lightweight silk fabric with a soft finish. Made with a twill weave. Usually printed with small figures on dark and light backgrounds. Suitable for dresses, robes, and scarves.

**Georgette.** Highly creped sheer silk fabric. Used chiefly for dresses and blouses.

**Grosgrain.** A fine cross-ribbed fabric of close texture having a heavy filling, which is sometimes made of cotton yarns. Ribs are rounder than in faille, heavier than in poplin. Used chiefly for ribbons and trimmings.

**Habutai.** Similar to China silk but heavier. A closely woven, pure-dye fabric. Used for lamp shades, dresses, blouses, lingerie, curtains.

**Lamé.** Silk in which metal threads form the pattern or the background Used for evening wear.

**Marquisette.** Very sheer silk fabric in the gauze weave. Sometimes called silk gauze. Used for evening dresses and trimmings.

**Matelassé.** A fabric having a raised figured pattern in a blistered quilted effect. Woven on a Jacquard loom. Used for dresses and blouses.

**Merveilleux.** An all-silk or silk-and-cotton mixture in twill weave. Used as lining in men's outer apparel.

**Moiré.** Watermark designs embossed on plain-weave fabrics that have crosswise ribs.

**Mousseline de soie.** Sheer transparent silk in a plain weave. Similar to chiffon but with a more open texture and a stiffer finish produced by the use of sizing. Used chiefly for evening dresses.

**Ottoman.** Heavy plain-weave fabric with wide, flat crosswise ribs that are larger and rounder than in faille. Filling may be cotton, silk, or wool. Used for dress coats, suits, trimmings.

**Pongee.** Also called tussah silk. Made from wild silk. Has a rough, uneven texture. Generally in its natural colors of cream to light brown, but may be dyed. Used for dress goods and household decoration.

**Radium.** A lustrous, supple fabric having the drapability of crepe and the crispness of taffeta. Plain weave. Used for women's dresses, slips, negligees, blouses, linings, draperies.

**Satin.** Silk fabric with a highly lustrous surface and usually a dull back. Made in different weights according to its uses, which vary from lingerie and dress goods to drapery and upholstery fabrics. May be made with a cotton back. Sometimes double-faced for use as ribbon.

**Shantung.** Low in luster, heavier and rougher than pongee. A plain weave in which large, irregular filling yarns are used. Sometimes used to describe a heavy grade of pongee made in China.

**Souple silk.** Silk dyed in the skein, only part of the sericin being removed.

**Surah.** A soft, strong silk with a twill weave. Used for dresses and scarves.

**Taffeta.** A smooth, closely woven fabric in a plain weave. Often weighted to produce its characteristic crispness. Sometimes has a moiré pattern. Used for dresses, suits, coats, and lingerie.

**Velvet.** Silk velvet has a silk pile and a silk back. Some velvets are made with a silk pile and a rayon or cotton back. *Transparent velvet* is a sheer velvet having a rayon pile and a silk back. *Panne velvet* has a special luster that is produced by pressing the pile in one direction.

*Test yourself on this chapter by answering these questions:*

1. Name the silk-producing countries. What is the cultivation of silk called?
2. Describe the life cycle of the silkworm.
3. What process in the production of silk is analogous to the spinning process for other fibers?
4. What is the difference between weighted silk and pure-dye silk?
5. Describe the degumming process and its effects on various types of silk fabrics.
6. For what purpose would you select silk rather than other fabrics? Why?
7. What finishing processes are given to silk fabrics?
8. What is spun silk? How does it differ from cultivated silk?
9. Why is silk weighted? What are the advantages of weighting? The disadvantages?
10. How does wild silk differ from cultivated silk? How does the difference affect the consumer?
11. Why are most wild-silk fabrics tan in color?
12. Name some fabrics usually made from wild silk.
13. For what purposes is pongee most desirable?
14. Why is silk not recommended for window curtains?
15. List the essential qualities of silk and show the effect of each quality on finished goods.

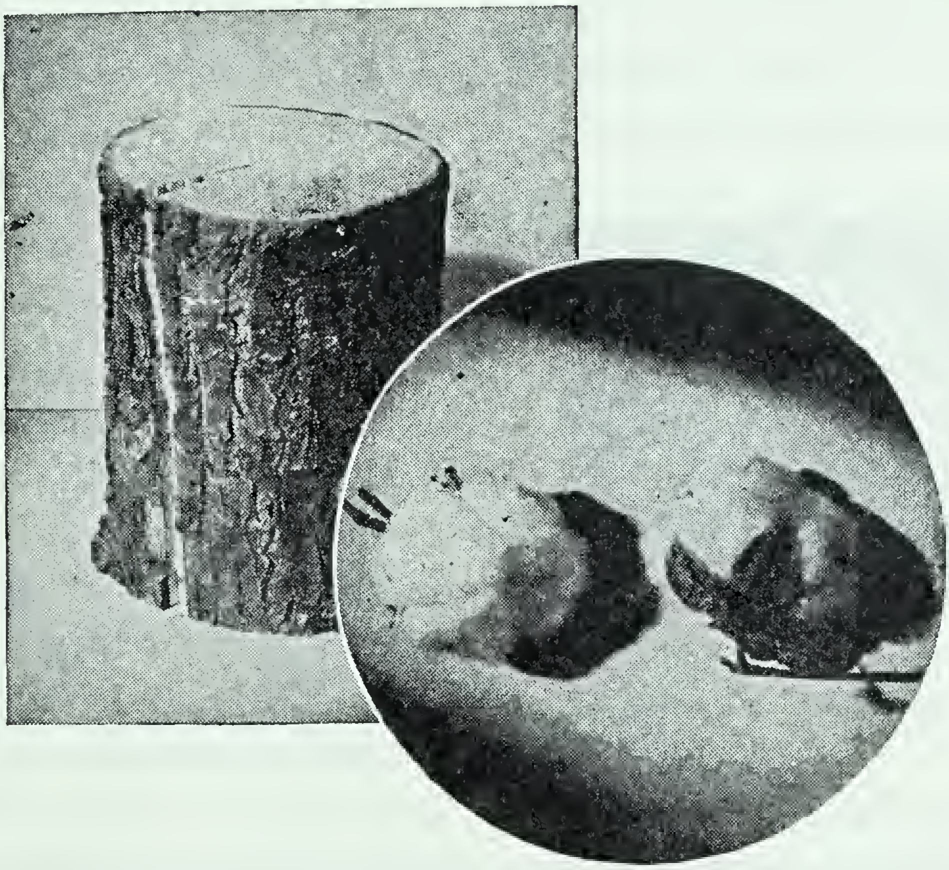
## Suggested Readings

Darby, W. D., *Silk, Queen of Fabrics.*
Dooley, W. H., *Textiles,* Chapters 16, 17.
Dyer, E., *Textile Fabrics,* Chapter 7.
Hess, K. P., *Textile Fibers and Their Use,* Chapter 3, Section 2.
Matthews, J. M., *The Textile Fibers,* Chapters 9, 10, 11.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 7.
Nystrom, P. H., *Textiles,* Chapters 17, 18, 19.
Small, C. P., *How to Know Textiles,* Chapter 15.
Wingate, I. B., *Textile Fabrics,* Chapter 7.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 8.

## CHAPTER XII

# RAYON: CELLULOSE MAN-MADE FIBER

Synthetic textile filaments were officially recognized in 1925, when the Federal Trade Commission permitted the use of the name *rayon* for man-made yarns obtained from cellulose or its derivatives. As there are several processes of making synthetic textile yarns, and as the production and types of yarns had increased and had been given various trade names, the Federal Trade Commission ruled again in 1937 that any fiber or yarn produced chemically from cellulose must be designated as rayon.



Wood pulp and cotton, the sources of cellulose, from which rayon is made.

**Early History.** The production of a synthetic fabric such as rayon had been prophesied as long ago as 1664 by Robert Hooke, the English naturalist. He believed that it was possible to make an "artificial glutinous composition, much resembling, if not full as good, nay better, than that excrement, or whatever other substance it be out of which the silkworm wire-draws his clew." In 1710, René A. de Réaumur, the French scientist, suggested the possibility of making silk filaments out of gums and resins—for example, threads of varnish. One hundred and thirty years later, in 1840, Louis Schwab invented an apparatus that drew synthetic filaments through small holes.

In 1855, Georges Audemars, a Swiss chemist, discovered how to make cellulose nitrate. This was the first step toward the nitrocellulose process of making rayon. Almost thirty years later, in 1884, Count Hilaire de Chardonnet produced the first synthetic textile fibers from nitrocellulose. He became known as the "father of rayon." Chardonnet obtained the original French patent and won the financial support that built the world's first rayon factory.

These and other chemists of their day, as well as those who are constantly experimenting today on new man-made fibers, have been guided by a desire to produce a beautiful, smooth, light, supple fabric with just the right amount of luster—the characteristics for which silk has long been noted—at a price that is within the income of every consumer.

The spinneret that forms the spinning solution into filaments.

**Basic Method of Producing Rayon Filament.** The natural process by which the silkworm transforms the cellulose of mulberry leaves into two fine filaments is duplicated in the process of making rayon.

A liquid substance of cellulose or of a cellulose derivative is forced through a metal cap or nozzle about the size of a thimble. This nozzle is called a spinneret because it performs the same function as the silkworm's spinnerets. The cap is usually made of platinum because that metal is not affected by acids or alkalies; it is perforated with small holes that are almost invisible to the naked eye. Through each of the tiny holes, a synthetic filament is extruded, which is solidified by a liquid bath or by warm air, as it comes from the spinneret. This is similar to the hardening by air of the raw-silk substance spun by the silkworm.

The number of holes in the spinneret may be varied, thus producing at one time any number of filaments of the same size. In a subsequent operation, these filaments are doubled and twisted in order to make any required size of rayon yarn.

**Rayon Yarn Count.** The count of rayon yarn is expressed in deniers, the unit of weight explained in Chapter XI. The denier of rayon yarn is controlled by the size and the number of holes in the spinneret. The number of deniers required to weigh one skein of yarn, 450 meters long (the standard length), is the denier, which indicates the size of the yarn in that skein.

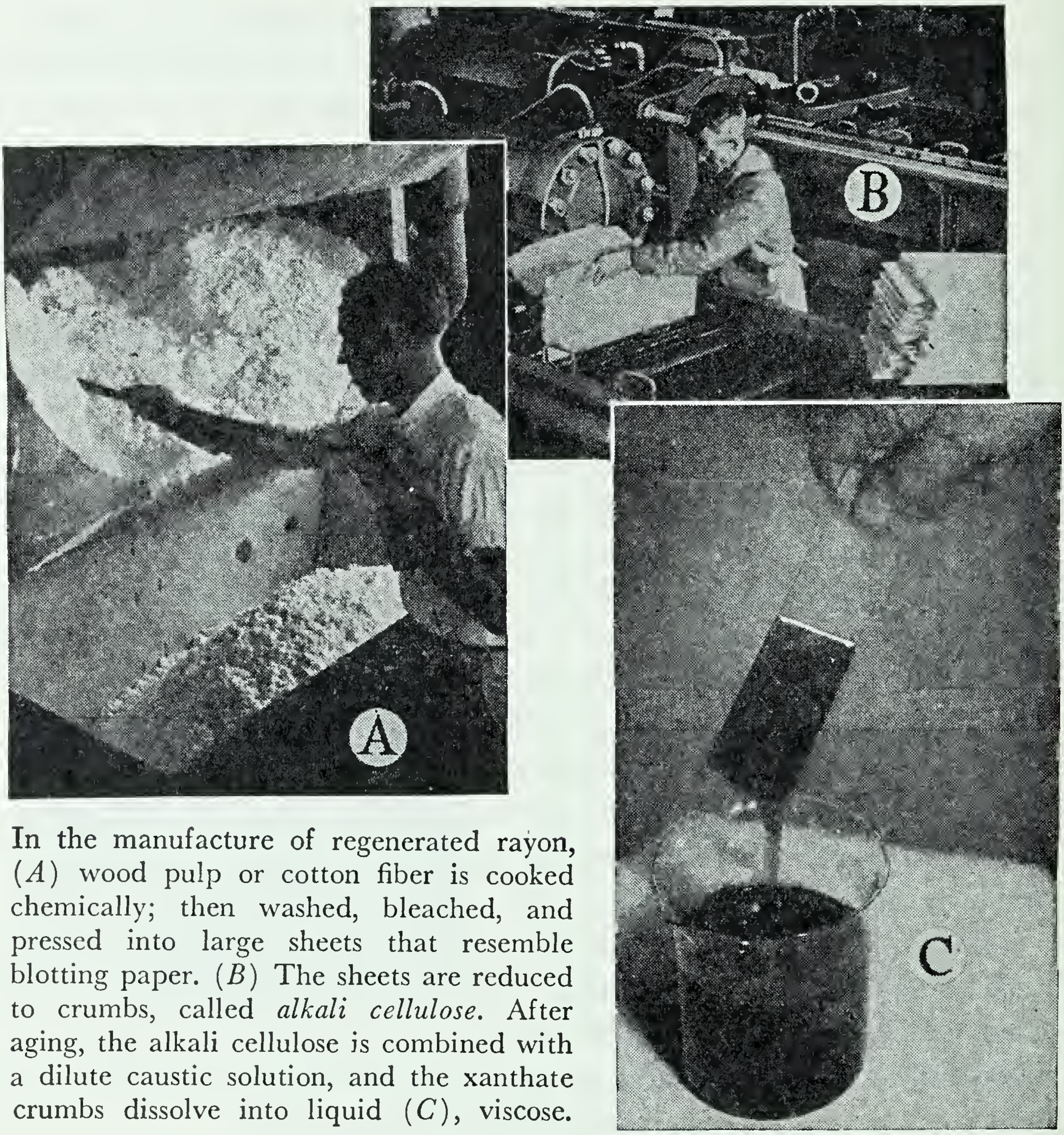
Because the sizes of yarns differ according to the purposes for which the yarns are intended, the weights of the skeins differ, even though the skeins are of the standard length. The finer the yarn, the less the skein weighs, and the lower the figure that expresses its weight in deniers.

Single rayon yarns may be composed of from 13 to 270 filaments, which may vary from 2.5 to 4 denier each. Thus, when 40 or more filaments are combined, the yarns will vary from 100 to 150 denier; these are the yarns generally used for rayon dress fabrics. Coarser dress-fabric yarns may run as high as 10 denier for a filament; the resultant denier of such yarns would naturally be higher than 150.

*Multifilament Yarns.* Extremely fine yarns—yarns less than 3 denier—are called multifilament yarns. These are finer than the finest silk filament, which is between 2½ and 3 denier. Multifilament rayon fabrics are the sheerest of all fabrics because the yarns used in their construction are finer than the finest silk threads.

**Delustering.** When rayon was first developed, the yarn had an objectionable luster. In the early days, a dulling effect was obtained by using tight twist in the manufacture of the yarn or by means of a calcimine coating as a final finish on the fabric. Today, rayon is easily delustered while the filament is being made by including colorless pigments in the spinning solution; of these, the most important is titanium dioxide. Rayon can be manufactured to retain a permanently high luster or a semidull or a dull appearance.

Rayon thus treated is referred to as delustered rayon, and it is preferable to rayon delustered in the finishing processes by the use of emulsions of oil, wax, or paraffin.



In the manufacture of regenerated rayon, (*A*) wood pulp or cotton fiber is cooked chemically; then washed, bleached, and pressed into large sheets that resemble blotting paper. (*B*) The sheets are reduced to crumbs, called *alkali cellulose.* After aging, the alkali cellulose is combined with a dilute caustic solution, and the xanthate crumbs dissolve into liquid (*C*), viscose.

**Methods of Producing Rayon.** There are four principal methods of making rayon. The fabrics differ in important characteristics because the methods differ in: (1) the raw material from which the cellulose substance is obtained; (2) the chemicals that change the cellulose into fluid form for spinning; (3) specific features of manufacture.

Three of the rayons, *viscose, cuprammonium,* and *nitrocellulose,* are classified as *regenerated rayons* because the original raw material, the cellulose, is changed chemically into another form, which is then changed—that is, regenerated—into cellulose again. This second change produces the final product—purified cellulose.

The fourth rayon, *acetate,* is known as *unregenerated rayon* because acetate filaments are not made from regenerated cellulose, but are formed from cellulose acetate, which is a derivative of cellulose.

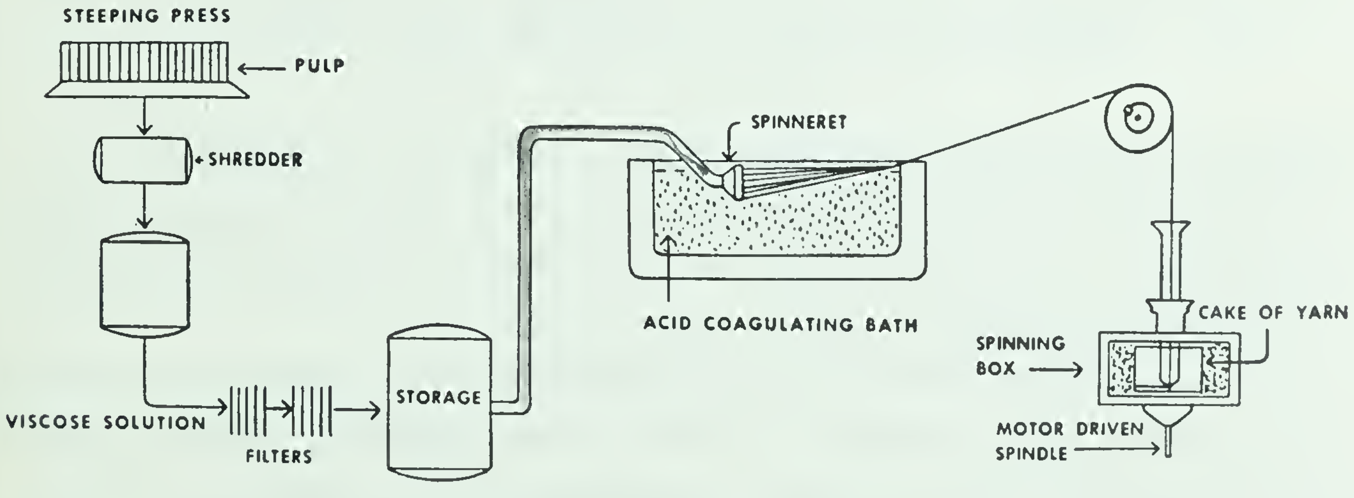
World production of rayon by these four methods in a typical normal year (1939) is shown in the following table:

| *Process* | *Percentage* | *Pounds* |
|---|---|---|
| Viscose | 80.65 | 925,000,000 |
| Acetate | 14.75 | 169,000,000 |
| Cuprammonium | 4.25 | 49,000,000 |
| Nitrocellulose | ·35 | 4,000,000 |

**Nitrocellulose Rayon.** Although Chardonnet produced the first man-made textile fibers from nitrocellulose, sixty years ago, the nitrocellulose process is no longer a significant factor in the world production of rayon.

In the nitrocellulose process, cotton linters are treated with a mixture of nitric and sulphuric acids. The linters are dissolved in a mixture of alcohol and ether, which forms a spinning solution called collodion. As this solution is forced through the spinneret, the alcohol evaporates and the filament hardens. Its nitrate element is removed by a sodium hydrosulphide treatment, yielding a filament of purified cellulose.

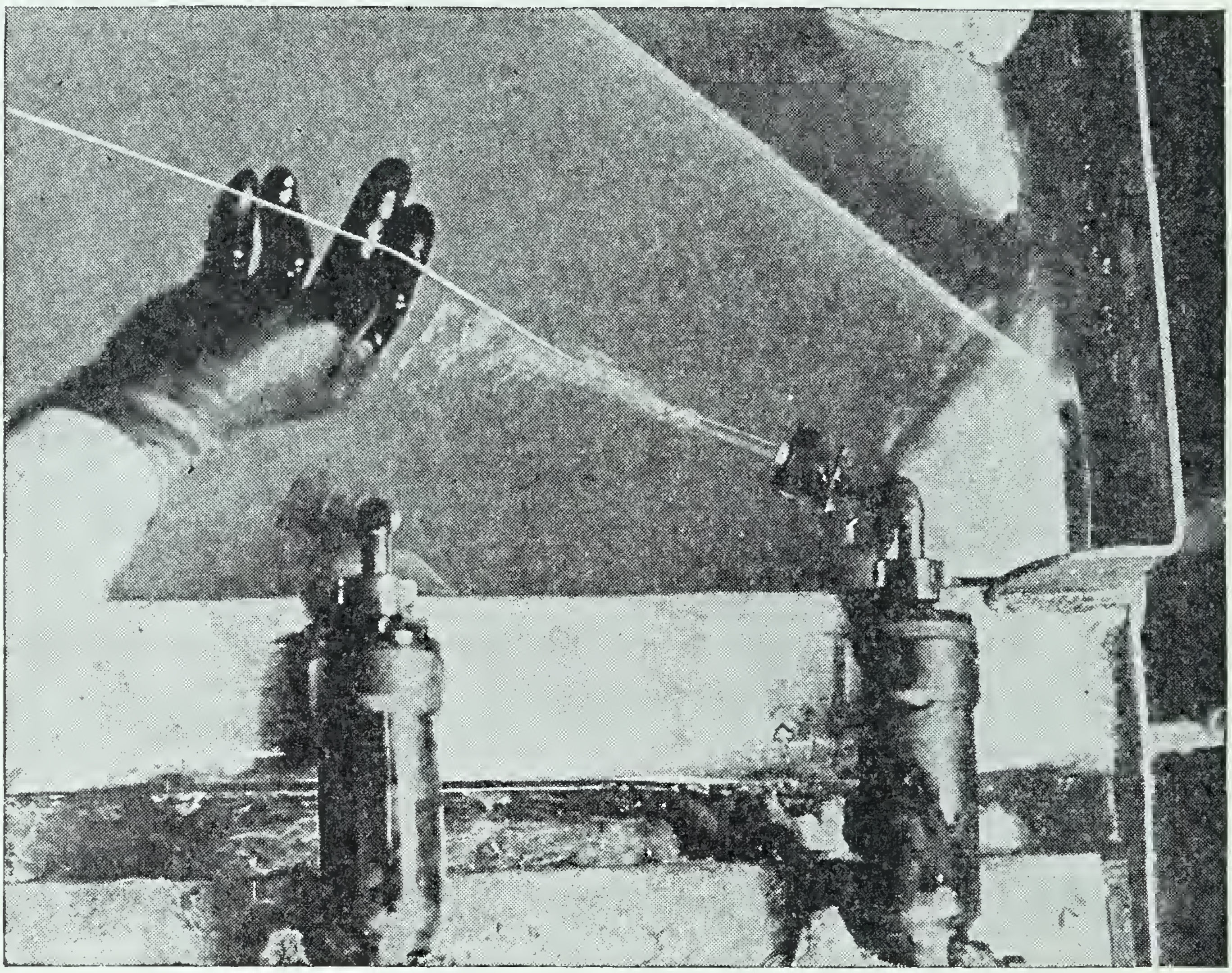
**Viscose Rayon.** Viscose rayon is made from wood pulp obtained from spruce, hemlock, and pine trees. The chemical process of dissolving wood pulp was first discovered in 1840 by F. G. Keller, a noted



PRODUCTION OF VISCOSE RAYON YARN

Saxon weaver. The viscose method of using wood pulp to manufacture rayon was developed in 1892, more than fifty years later, by C. F. Cross and E. J. Bevan, two English scientists. The first viscose manufacturing plant in the United States was established in 1910.

In the viscose process, the wood pulp is soaked in caustic soda to produce alkali cellulose. This substance is broken up into fluffy white flakes or grains called cellulose crumbs, which are aged for two or three days under controlled temperature and humidity. Liquid carbon disulphide is then added; this turns the cellulose crumbs into xanthate, a light-orange substance, still in crumb form.



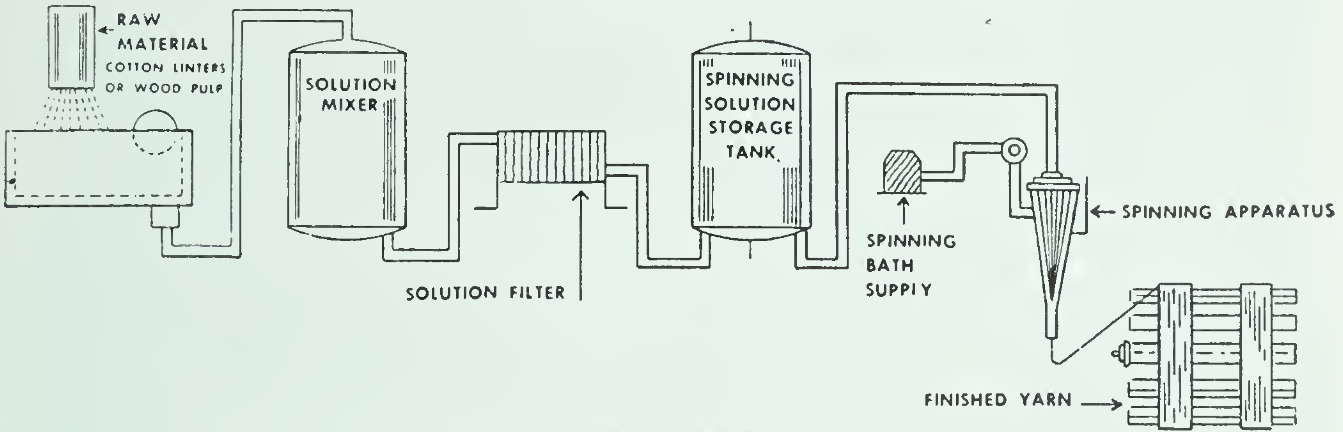
Liquid viscose, after being forced through the many fine holes of the spinneret, in a short space becomes separate rayon filaments, which, farther on, form the rayon thread clearly shown in the gloved hand.

The xanthate crumbs are dissolved in a weak solution of caustic soda and transformed into a thick viscous solution, called viscose, resembling honey in color and consistency. If the rayon is to be delustered, titanium dioxide is added at this point. The viscose is aged, filtered, and vacuum-treated to remove air bubbles, as they would cause the filament to break. The viscose is then forced through the holes of the spinneret into sulphuric acid, which hardens the newly formed rayon filaments.

Twist is inserted in the hardened filament, which is finally washed, bleached, dried, and wound into skeins or on cones or spools ready for manufacture into fabric.

Rayon fabrics made by the viscose process are known by such trade names as Acme, Belmose, Chalkelle, Chardonize, Crown, Delray, Dulesco, Du Pont, Enka, Hampton, Hartford, Lion, Lolustra, Nardura, North American, Premier, Skenandoa, Spun-lo, Sunbeam, Sunmist, Vistra.

**Cuprammonium Rayon.** The cuprammonium process of manufacturing rayon was first developed by L. H. Despaisses in France in 1890. This kind of rayon is made from cotton linters, which are boiled with caustic soda and soda ash, bleached with chlorine, and then washed and dried. The pulp is dissolved in copper oxide and ammonia, forming a solution ready for spinning. The name cuprammonium is derived from these two substances.



PRODUCTION OF CUPRAMMONIUM RAYON YARN

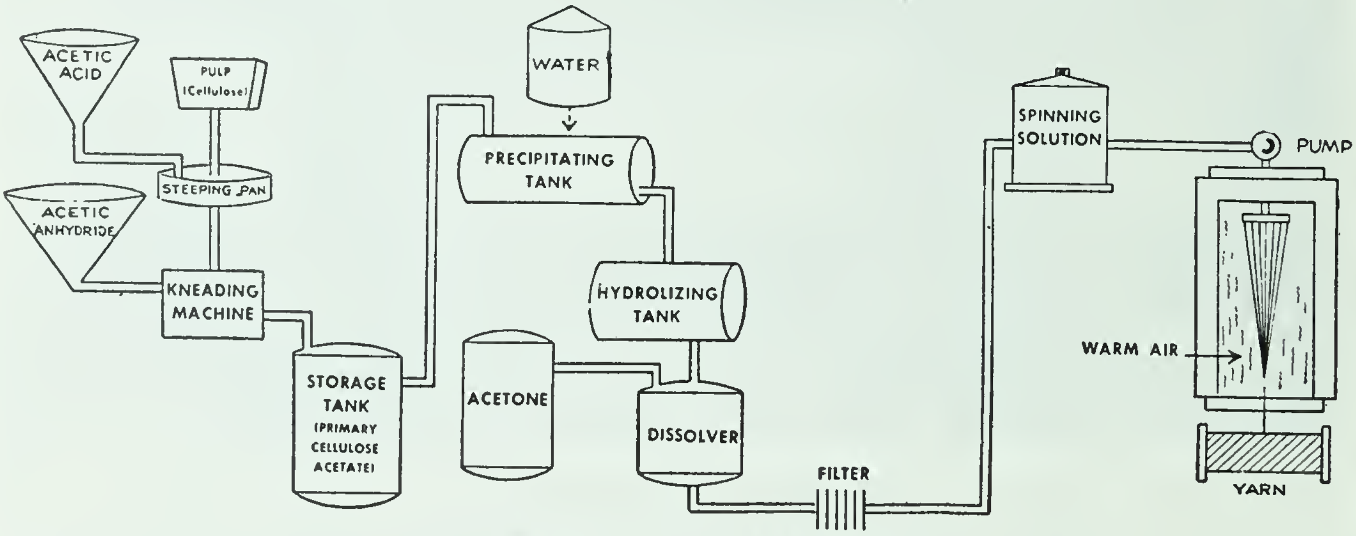
The spinning solution is forced through large holes in a spinneret, which are intentionally larger than the diameter of the filament will be, because the filament is to be stretched and twisted to a finer diameter by a process called *stretch spinning,* which subjects the filament to tension while it is being hardened. This stretch-spinning feature was developed and patented by E. Elsaesser of Germany.

As the spinning solution is pumped through the large-sized holes of the spinneret, it passes into a glass funnel, through which flows soft deaerated water at a constant temperature. On its way through the funnel, the filament is stretched and twisted. As it leaves the funnel, the filament enters a bath of mild sulphuric acid, which removes the copper and ammonia, leaving a solidified filament of pure cellulose, which is ready to be wound in skeins or on cones for the finishing and weaving processes. Final washing and bleaching are not required because these are initial steps in the processing of the cotton linters.

The stretch-spinning feature of the cuprammonium process produces an unusually fine, strong yarn that can be given a great amount of twist. It has greater elasticity than other rayon filaments. The fine threads can be woven into the sheerest of fabrics, and are especially appropriate for hosiery. The high twist contributes to drapability.

Rayon fabrics made by the cuprammonium process are known by such trade names as Aristocrat, Bemberg, Imperial, Matesa, Napon, Nupronium.

**Cellulose Acetate Rayon.** The cellulose acetate process of manufacturing rayon was developed in England in 1918 by Henri and Camille Dreyfus. In the United States, their product is known as Celanese. Cellulose acetate rayons were developed much later by manufacturers in this country.



PRODUCTION OF ACETATE RAYON YARN

Cellulose acetate rayon is not a pure cellulose product like viscose and cuprammonium. Although it is made principally from the cellulose derived from cotton linters, the pulp is treated differently and becomes a chemical compound of cellulose. The pulp is steeped in acetic acid and allowed to age for a period under controlled temperature. After aging, it is mixed with acetic anhydride, which transforms it into a thick, clear liquid—cellulose acetate.

After further aging, the cellulose acetate solution is precipitated as pure white flakes by running through water. The flakes are dried and then dissolved in acetone, and filtered several times to remove impurities. The result is a clear, white spinning solution of the consistency of sirup. If delustered yarn is required, titanium dioxide is added at this stage.

Cotton linters are being prepared for the first stage of manufacturing cellulose acetate rayon.

The spinning solution is then forced through a spinneret. Instead of passing through a liquid bath, the solution passes through warm air, which evaporates the acetone and solidifies the filament. The filament is then ready for winding on spools, cones, or bobbins. No washing or bleaching is required as the solution was cleaned and filtered before it passed through the spinneret.

A cake of long-filament rayon yarn.

The rayon filament produced by the acetate process differs from the other rayons not only in the chemicals used to digest the cellulose raw material but in the chemical nature of the final product. It manifests different characteristics and requires different dyes. Acetate filament is thermoplastic; that is, it may be softened or plasticized by application of heat. Embossed effects, such as moiré patterns, are permanent on acetate rayon.

Acetate rayon fabrics are known by such trade names as Acele, Aceta, Celanese, Chacelon, Crown Seraceta, Du Pont Acele, Eastman, Koda, Tubize.

**Spun Rayon.** The long, continuous rayon filaments produce rayon fabrics having smooth surfaces or crepe surfaces. The filament can be adapted for other effects by cutting it into short uniform lengths of from ½ to 9 inches. These lengths are spun into yarns similarly to the spinning of cotton

Staple fibers from which spun rayon is made.

or wool. Such spun-rayon yarns have an entirely different character from the ordinary rayon yarns.

According to the amount of twist inserted in the spinning process, spun-rayon yarn can be made stronger, less lustrous, and adaptable to napping and other finishes, so producing fabrics that resemble wool, linen, or cotton. Such short-staple rayon can also be combined with any of the natural fibers to make effective and useful fabrics; this blending would not be possible with the long rayon filament.

Thus, spun rayon provides new finishes and a variety of low-priced fabrics that formerly were made only from natural fibers, with a consequently higher production cost:

Some spun-rayon fabrics are known by such trade names as Avisco, Fibro, and Teca; there are many others that do not have specific trade names.

**Judging Rayon Fabrics.** In studying each of the natural fibers, cotton was rated highly for its economy and versatility. It was shown that linen even excelled cotton in certain qualities, such as strength, luster, absorbency, cleanliness, and crispness. With respect to warmth and resiliency, wool and silk take first place.

The development of a man-made fiber possessing many of the above-mentioned prized qualities of the natural fibers is a tribute to the ingenuity of man. If the supply of the natural fibers were insufficient or even nonexistent, man-made fibers could fully meet the situation.

*Strength.* Rayon is considered half as strong as silk; yet it produces a durable, economical, and serviceable fabric whose smoothness of surface withstands the friction of wear. Unlike silk, rayon does not deteriorate with age; it is resistant to dampness and salt air.

Strength combined with sheerness of construction is possible in rayon fabrics by means of multifilament yarns. This increased tensile strength is especially desirable in hosiery. High-tenacity yarns afford a lightness with strength that is unsurpassed even by silk.

Smooth-surfaced rayon fabrics are unusually slippery. Therefore, the seams of rayon garments will slip unless the French seam or the flat felled seam is used. Also, when cut on the bias, loosely constructed rayon fabrics may slip.

*Crease Resistance.* Because rayon lacks the elasticity natural to wool and silk, it creases readily; but it should be remembered that the resistance of a fabric to creasing depends on the kind of yarn, the weave, and the finishing process. For example, the extremely fine filaments used in multifilament rayons have a greater resistance to creasing. Any of the crepe surfaces produced by tightly twisted yarns also resist creasing. Fabrics treated with one of the better patented crease-resistant finishing processes are highly resistant to creasing. Also, a soft surface produced by napping, typical of spun rayon, has some degree of crease resistance because of the softness and flexibility of the short staple, which recovers easily from wrinkles.

*Drapability.* Rayon possesses a marked quality of drapability because it is a naturally heavy pure-dye fabric. The filament can be made as coarse as desired, depending on the holes in the spinneret, and the yarn can be made heavy without the use of metallic filling, so producing body substance in the fabric.

Acetate rayon has a high degree of drapability because of its greater weight. Cuprammonium rayon is especially suitable for drapery fabrics.

*Heat Conductivity.* Viscose and cuprammonium rayons are good conductors of heat and are therefore appropriate for summer clothing. In heat conductivity, acetate more nearly resembles silk, which is a nonconductor of heat; therefore, acetate may be used for warmer clothing. Spun rayon, whatever the type of rayon, is adaptable for winter apparel because the napped finish is insulative.

*Absorbency.* Viscose and cuprammonium rayons are suitable for summer underwear because, like silk, these rayons absorb moisture readily. Acetate rayon absorbs only half as much moisture as viscose and cuprammonium; it absorbs slowly and dries quickly. This quality makes it highly resistant to perspiration and to odors, which explains its widespread use for linings. Low moisture absorbency, combined with an insulative quality, makes acetate rayon an excellent fabric for bathing suits.

*Cleanliness and Washability.* The smoothness of the rayon fiber produces a hygienic fabric that sheds dirt and washes easily. Rayon will not become yellow when washed or dry-cleaned; white rayon remains white. Although rayon loses strength when wet, rayon fabrics can be laundered and dry-cleaned as readily as any other fine fabric if they are properly handled. Rayon regains all its natural strength after laundering.

*Shrinkage.* Because the rayons differ to some extent in fiber characteristics, the tendency to shrinkage differs. In viscose and cuprammonium rayon, the percentage of shrinkage is similar to that of cotton. Acetate rayon shrinks less than other rayons; in the flat weaves, acetate does not shrink at all. Crepe weaves or knitted fabrics always shrink to a certain extent because of the nature of the construction.

When combined with wool in sufficient quantity, rayon helps to overcome the great amount of shrinkage that is characteristic of wool. All spun rayons can be sanforized, which makes them especially suitable for apparel that must be frequently washed.

*Fastness of Color.* Rayon fabrics absorb dyes more evenly than any other fiber. Colored rayons have a high resistance to sunlight; they withstand strong light better than silk. This property makes rayon especially adaptable for window curtains.

Pigmented rayon, in which the dyestuff is put into the spinning solution, thus becoming an integral part of the yarn, is absolutely fast to washing. However, pigmented rayons are not produced in large quantities and are not widely used, as there is not a large sustained demand for specific shades over a period of time.

*Decorative Effects.* Rayon is often combined with other textile fibers with resulting novel and decorative effects. Moiréeing is always permanent when embossed on an acetate rayon fabric. Similarly, pleats are permanent in acetate rayons.

*Resistance to Mildew and Moths.* Like cotton, the viscose and cuprammonium rayons have a tendency to mildew. Acetate rayon does not mildew, and is therefore an ideal fabric for shower curtains.

Moths are not attracted to rayon fabrics; mothproofing treatments are not necessary.

## Newly Developed Rayon Yarns and By-Products

The many types of rayon yarns that have been produced since this man-made textile fiber was first introduced indicate the efforts that the rayon manufacturers are making to improve this wonderful new product. During World War II, the military requirements of the

United States Government for unusually sturdy fabrics gave additional impetus to the development of new rayon yarns as well as valuable by-products of the rayon processes.

**High-Tenacity Yarns.** High-tenacity yarns have been developed for purposes where fabrics of extra strength are required: for example, tackle twill and similar specially durable fabrics required for military purposes. High-tenacity yarns produced by the viscose process are Cordura and Tenasco.

**Fortisan.** Fortisan is a high-tenacity yarn of extremely fine filament. It starts with cellulose acetate as a base and is regenerated into pure cellulose. When first produced, its tenacity was 7 grams per denier, twice as great as the finest silk, which runs 3.5 per denier. Compared with all other rayons, which lose considerable strength when wet, Fortisan yarns lose only about 18 per cent when wet. This high tensile strength in extremely fine filaments permits the production of fabrics with unusually sheer construction. Fortisan was developed by the Celanese Corporation.

**Fiber D.** Fiber D is the name given to a new fiber with a durable crimp that may be recovered even if temporarily altered during processing. Crimp gives bulk to yarn and a wool-like appearance and feel to fabrics. When Fiber D is treated with Zelan finish, it acquires a soft feel similar to that of carpet wool. It is used as pile yarns in rugs and carpets. Fiber D was developed by the Du Pont Company.

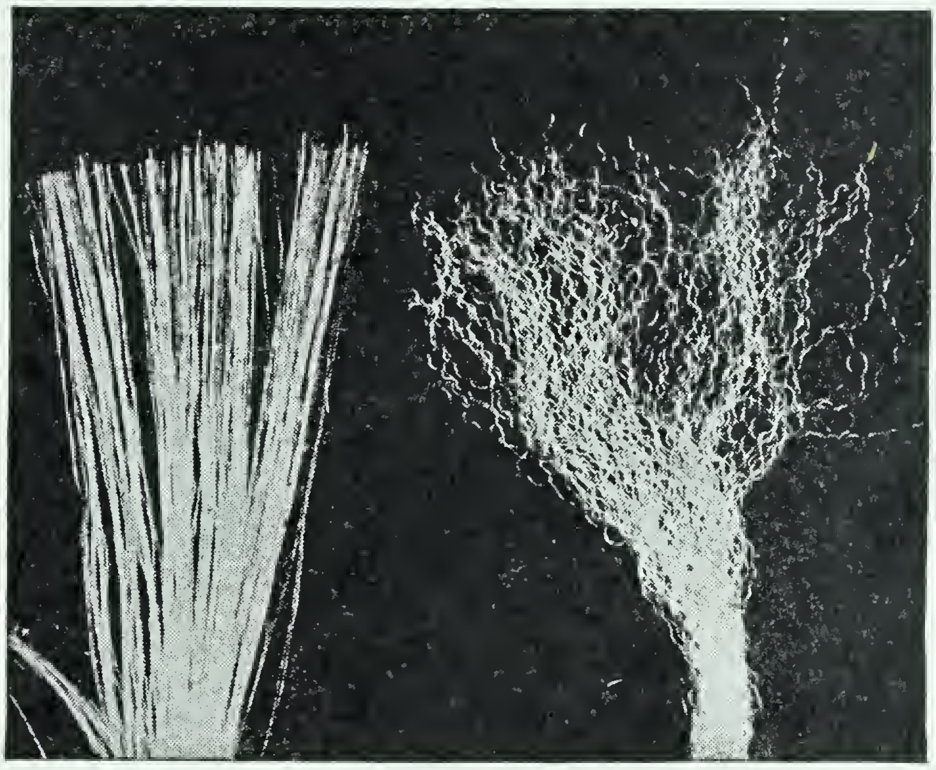
**Fiber G.** Fiber G is the result of adaptation of a new spinning method for rayon, developed by the Du Pont Company. This yarn can be made by any of the rayon processes. It is an entirely new type of strong rayon and is believed to bridge the gap between ordinary synthetic textile fibers and nylon, as it has superior wet strength when compared with ordinary rayons.

Its widest use may be in the field of industrial textiles, but it is expected that it will be adaptable for such products as shoe fabrics and bathing suits.

Fiber G was limited, when first produced, to a 240 denier containing 120 filaments and a 1100 denier containing 480 filaments.

**Celta.** Celta is a hollow filament produced by the cuprammonium process, which makes a light, soft, fine but strong yarn similar to the multifilament Bemberg yarn. Celta is used chiefly for lingerie.

**Cellophane.** The viscose process produces the thin, smooth, transparent, and lustrous sheets of cellulose that are known as cellophane. This by-product has great commercial value because of its many unique properties. It is flexible and insulative; odorproof, greaseproof, and moistureproof. Cellophane may be made in many colors; it is adaptable for combination with textile fabrics. Similar to cellophane but differing in its manufacture is Kodapak, which is produced by the acetate process.



At the left is a group of rayon fibers produced by the regular viscose process. At the right is a group of Fiber D rayon fibers. Both pictures are longitudinal views without magnification.

**Monofil.** When the viscose solution is forced through only one minute hole in a spinneret, a single-filament yarn of unlimited length and resembling horsehair may be produced. The yarn is called monofil. It is of value in the millinery industry as a substitute for horsehair, the use of which has always been limited by its short length.

**Visca.** When the viscose solution is forced through a narrow slit instead of a small single hole in a spinneret, a lightweight but strong ribbonlike synthetic material is produced that resembles straw. It is called visca. These narrow strips are useful in making costume accessories and in the manufacture of upholstery and millinery. They can be combined with other fibers to produce lustrous effects.

**Solka.** Solka is manufactured from spruce wood pulp by the viscose process. It is quite similar to cotton, but contains more cellulose and has a much shorter fiber. Solka is spun into coarse yarns, which are used for upholstery and drapery fabrics and for rugs, shoes, and handbags.

**Bubblfil.** Bubblfil, an innovation in yarn manufacture, produces filaments having a chain of separate air pockets or bubbles, each one tightly sealed from the adjacent bubble. These yarns are extremely light in weight and have the novel properties of great buoyancy and compressibility in addition to a high degree of heat insulation and marked resiliency. Bubblfil would be used similarly to sponge rubber, cellular rubber, and kapok.

**Lumarith.** The Celanese acetate process produces a plastic called Lumarith—a transparent sheeting pliable enough to wrap a powder puff but rigid enough for shaping into a lunch box. It will not stretch or shrink, and is dustproof and resistant to moisture.

**Nonshatterable Glass.** The use of an acetate filler between layers of glass has produced nonshatterable glass, which serves several purposes but is an especial boon to the automobile industry.

## Glossary of Rayon Fabrics[1]

**Alpaca.** A fabric originally containing hair of the alpaca. Now made in rayon-and-wool blends. Plain weave. Used for women's spring coats, suits, sportswear.

**Alpaca crepe.** Two-ply. Gives somewhat the appearance of wool. Term used for a soft, dull rayon combination crepe.

**Bark crepe.** A fabric that produces the effect of rough bark on trees. A crepe with extreme surface interest.

**Batiste.** Soft, thin lightweight fabric. Made of various fibers, including spun rayon. White, colors, or printed. Plain weave. Used for handkerchiefs, lingerie, dresses, blouses.

**Bedford cord.** A corded material that can be made with various fibers, particularly adaptable to rayon. Has tailored appearance. Cords run lengthwise. Novelty weave, a type of raised plain weave. Used for riding habits, coats, sportswear, suits.

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[1] Courtesy of American Viscose Corporation, adapted from *Rayon Fabrics.*

**Bengaline.** A ribbed rayon fabric. Ribs run crosswise. A substantial somewhat dressy fabric resembling poplin, but with a heavier rib. Plain weave. Used for women's formal coats, suits.

**Bird's-eye.** A distinctive weave; small diamond twill pattern featuring a small dot in the center that resembles a bird's eye. Seen in bird's-eye rayon piqué and rayon diapers.

**Broadcloth.** A fine closely woven fabric originally made in cotton for shirtings and dress goods, and in wool for dress goods, suitings, and coatings. Now also made in rayon in shirting and dress weights. Also in spun-rayon-and-wool blends in suitings, coatings, and wool-like dress weights. Plain weave. In all-rayon, used for sportswear, shirts, pajamas. In spun-rayon-and-wool blends, used for women's suits, coats, and winter dresses.

**Brocade.** Originally, heavy silk with elaborate pattern. Now made extensively in rayon. Brocade has slightly raised designs or an embossed appearance as contrasted with damask, which has a very flat pattern. A contrast of surfaces in the weave may produce design, or different colors may be used. Novelty weave, Jacquard. Example: satin or twill figures on plain, twill, or satin grounds. Used for draperies and upholstery; in lighter weights, for formal evening wear.

**Brocatelle.** A fabric similar to brocade but having designs in high relief. Weave is usually a filling satin or a twill figure on plain or satin ground. Used for draperies, upholstery.

**Canton crepe.** A crepe with modified rippled texture. Heavier than crepe de chine.

**Casement cloth.** A term covering many curtain fabrics. Variety of weaves are used. Now made in rayon.

**Cavalry twill.** A sturdy, substantial fabric with a pronounced diagonal raised cord, now made in spun rayon. Twill weave. Used for sportswear, uniforms, riding habits, ski wear.

**Challis.** Originally a silk-and-worsted fabric. A light, soft, pliable fabric, now also made in spun rayon or spun-rayon-and-wool blends. Usually printed in small floral designs, but may also be plain color. Plain weave. Used for dresses, negligees, ties, shirts, pajamas.

**Chambray.** A plain-weave fabric generally characterized by a colored warp and a white filling, giving a mixture effect. Well known in cotton; may be had in spun rayon. Used for sportswear, women's and children's summer wear, men's shirts, pajamas.

**Chenille.** A tufted fluffy yarn that looks like a caterpillar. Also a fabric made from such a yarn. Used for rugs, mats, spreads, knitting yarn, robes.

**Chiffon.** (1) Descriptive term indicating light weight, as chiffon velvet, chiffon taffeta. (2) Thin gauzelike fabric with soft or sometimes stiff finish. Plain weave. Used for evening dresses, formal blouses, trimmings.

**Corduroy.** A fabric having ridges or cords in the pile. Formerly made in cotton only, may also be made in rayon and cotton combinations. Variation of plain weave. Used for men's and women's sportswear, children's wear, infants' wraps, slip covers, draperies.

**Covert.** Originally a medium-weight suiting of woolen or worsted yarns. Now developed in spun rayon or spun rayon and wool. In dress as well as suiting weights. It has a speckled effect in color. Twill weave, sometimes satin. Used for sportswear, riding habits, suits, coats, raincoats.

**Crash.** Term applied to fabrics having coarse uneven yarns and rough texture. Usually made in linen, now also made in rayon. Plain or twill weave, or twill variations. Used for sportswear, men's, women's, and children's summer suits and coats, draperies.

**Crepe.** A fabric made of highly twisted yarn extremely versatile in texture, ranging from a fine, flat crepe to pebbly and mossy effects and, in extreme cases, to barklike, roughish textures. Rayon is used the most extensively of all fibers in crepes. Fabrics of this family have a wide range of suitability in women's wear. Usually plain weave.

**Crepe de chine.** A crepy fabric that, in texture interest, falls between a canton and a flat crepe. At present used mainly for lingerie; formerly for dresses.

**Crepe georgette.** A lightweight semisheer crepe.

**Crepe marocain.** Heavier dress-weight crepe. An exaggerated canton crepe in texture.

**Crepon.** Originally wool crepe. Now also made in rayon. Has a wavy texture with waves running lengthwise. Mostly used for prints.

**Damask.** Flatter than brocade and reversible. Jacquard weave. Satin or twill filling figures woven on a plain, twill, or satin ground formed by warp. Used for upholstery and hangings. In lighter weights, for formal evening wear and wraps; also tablecloths, napkins, bedspreads, face towels.

**Doeskin.** Twilled fabric napped on one side. May be made in spun rayon as well as in wool or cotton. Twill or satin weave. Used for sportswear, coats, suits.

**Duvetyn.** Originally a soft woolen fabric with fine downy back, now also made in spun rayon and wool. Twill or satin weave. Used for coats, suits, dresses.

**Eponge.** Soft, loose, spongy fabric similar to terry cloth. Novelty weave. Used for sportswear, summer suits, coats.

**Etched-out fabrics.** (Also called burnt-out.) A fabric containing two different yarns in which pattern effects have been produced by acid. The acid is used to treat one of the yarns so as to remove certain portions of it, creating a patterned effect. Any of the three basic weaves or their variations. Used for dresses, curtains.

**Faille.** A flat-ribbed fabric having body and drape. Ribs are wider and flatter than in grosgrain. Tailors well and wears well if not too loose in weave. Variation of plain weave. Used for women's spring coats, suits, dresses.

**Felt.** An unwoven fabric that can now be made by using wool and a percentage of rayon.

**Flannel.** Soft lightweight fabric with slightly napped surface. Originally made in wool; now made extensively in spun rayon or in spun-rayon-and-wool blends. Plain or twill weave. Used in medium weight for dresses and sportswear; in light weight for shirts and sports blouses, children's wear; in heavier weight for suitings and coatings.

**Flat crepe.** Smoothest of crepe family. Inaccurately called French crepe.

**Foulard.** Soft, light fabric, originally silk or wool; may now be made in rayon. Usually printed. Twill weave. Used for dresses, neckties.

**Frieze.** Originally a heavy woolen overcoating with nap on the face. Can be made in spun rayon and wool in similar texture. Double-cloth weave with twill construction. Used for overcoats.

**Frise.** Pile fabric of uncut loops. Variation of plain weave. Used for upholstery.

**Fur fabrics.** Large class of pile fabrics of spun rayon or other fibers, imitating various furs by dyeing and special finishing. Fabric can be either woven or knitted. Any variation of basic weaves. Used for popular-priced winter coats and trimmings.

**Gabardine.** A firm, durable fabric with a diagonal rib. Modern gabardines are made in spun rayon, wool, cotton, or blends in both dress and suiting weights. Twill weave. Used for men's, women's, and children's wear, sportswear, suits, uniforms, riding habits, fabric shoes, raincoats.

**Gauze.** A light, sheer fabric having an open, lacy effect. In rayon, thin curtain fabrics are often called gauze. Leno weave.

**Gros de Londres.** Cross-ribbed dress fabric with heavy and fine ribs alternating, or ribs of different colors. Plain weave or plain variations. Used for dresses, evening wear.

**Grosgrain.** Firm, stiff, closely woven ribbed fabric. Much grosgrain ribbon is made of rayon. Cords heavier and closer than in poplin, more round than in faille. Plain weave or plain variation. Used for neckties, ribbons, trimmings, millinery.

**Hopsacking.** A rough-textured fabric with open weave. Resembles sacking, as name implies. Plain weave. Used for men's slacks and shirts, women's sportswear, draperies.

**Jersey.** Plain knitted or ribbed. Originally wool, now featured extensively in rayon in plain and novelty effects. May also be had in rayon and wool. Used for women's dress fabrics, sportswear, underwear.

**Lamé.** Any fabric using metal threads in warp or filling or for decoration. Any weave. Used for formal evening wear.

**Linen-textured rayon.** A large and important category of rayon fabrics having the distinctive textures of linens. These range from sheer handkerchief-linen texture to heavier, rougher butcher-linen texture. Usually plain weave. Used in lighter weight for handkerchiefs, women's and children's dresses, tablecloths, towels, sheets, pillowcases; heavier weights for summer coats, suits, sportswear.

**Madras.** Soft fabric for shirts. May be white or yarn-dyed. Variation of plain or twill weave. Many fancy effects in weaving with corded stripes or small figures. True madras has woven figures. Originally made in cotton, now also made in spun rayon. Used for shirts, sportswear.

**Marquisette.** Loose, open, sheer fabric of leno construction in which warp yarns are in pairs, whipping around one another between picks of filling yarns. Each thread is locked. Extensively featured in rayon. Novelty leno weave. Used for curtains, evening wear.

**Matelassé.** Cloth having a raised pattern as if quilted or wadded. Rayon matelassé crepe looks somewhat blistered. A novelty double weave showing a quilted effect: plain, twill, or satin. Used for women's dresses, evening wear.

**Milanese.** A type of warp-knit fabric used in gloves and women's underwear. Milanese has a distinctive diagonal cross effect. Originally silk, now also rayon.

**Mock romaine crepe.** Similar to romaine crepe in texture and appearance. Different filling construction.

**Mogador.** Originally a tie silk. Now also in rayon. Resembles fine faille. Plain weave. Used for ties, sportswear.

**Moiré.** Usually a taffeta or faille with a watered or waved effect, produced by a special finish. Steaming or wetting will destroy the pattern except on acetate rayon. Plain weave. Used for women's dressy coats, suits, dresses, evening wear, bathrobes, dressing gowns, draperies, bedspreads.

**Mossy crepe.** Sometimes called "sand crepe." Fabric with texture giving fine moss effect.

**Mousseline.** Taken from "mousseline de soie," meaning "silk muslin." Now made in rayon. Firmer than chiffon, stiffer than rayon voile. A sheer, crisp, formal fabric. Plain weave. Used for evening wear, collars, cuffs, trimmings.

**Net.** Originally all nets and laces were made with a needle or with bobbins. In modern nets the same effect is produced by machinery. There are a variety of meshes. Rayon nets can be soft or crisp. Used for curtains, trimmings, evening gowns, veiling; heavier nets for tablecloths, bedspreads, curtains.

**Ninon.** A sheer, crisp fabric, heavier than chiffon. Plain weave. Used for evening wear and curtains.

**Organza.** Thin, transparent, stiff, wiry rayon fabric. Crushes or musses, but is easily pressed. Plain weave. Used for evening dresses, trimmings, neckwear.

**Ottoman.** Heavy cross-corded fabric having larger and rounder ribs than faille and bengaline. Variation of plain weave. Used for evening wraps, formal coats, suits.

**Oxford shirting or suiting.** Basket-weave fabrics, which may be made in plaid or two-color effects. Heavy qualities suitable for summer suits, skirts, jackets; lighter weight for sportswear, shirts.

**Pin check.** Fine check made with different-colored yarns. Usually woven. Smaller than shepherd's check.

**Piqué.** Originally a cotton fabric with raised stripes or welts running lengthwise or on diagonal. Now also made in rayon. Knit construction may give similar effect, not so crisp. Variation of plain weave. Used for sportswear, children's wear, summer evening wear.

**Plush.** Cut-pile fabric with a pile of greater depth than velvet. Now made in rayon. Variation of plain weave. Used for coats, trimmings, upholstery.

**Poplin.** Originally made in silk. Rayon poplin is a cross-ribbed fabric between taffeta and bengaline in weight and appearance. The effect is created by a coarser yarn in the filling than in the warp. Plain weave. Used for women's wear, shirts, pajamas.

**Ratiné.** A fabric made of nubby or knotty yarns. Frequently rough and spongy in texture. Plain weave or variation of basic weaves. Used for sportswear, dresses, draperies.

**Rep.** A fabric with narrow ribs running lengthwise. Variation of plain weave. Used for women's wear, neckties, draperies, upholstery.

**Romaine crepe.** A heavy sheer combination rayon crepe similar to crepe alpaca but slightly flatter.

**Satin.** A fabric with a lustrous surface. Rayon fabric with satin weave. *Crepe satin* is soft and lustrous; used for women's dresses, formal wear, negligees, draperies, and bedspreads. *Panne satin* is a stiff slipper satin; used for formal evening or bridal wear. Panne or crepe satin is used for *lining satin,* usually lighter in weight than dress satin. Panne or crepe satin can be finished as *wash satin* for blouses and lingerie. *Upholstery satin* is heavy, usually with cotton back.

**Seersucker.** A lightweight fabric with crinkled stripes. Does not require ironing after laundering. Originally made in cotton, now also featured in rayon. May be plain, printed, or cross-dyed. Plain weave. Used for women's wear, children's wear, sportswear, and, in heavier weights, for men's summer suits.

**Serge.** A twill fabric with a smooth finish. The twill is very fine and close. Made of spun rayon, wool, cotton, or blends. Twill weave. Used for women's dresses, suits, coats, children's wear, men's suits.

**Shantung.** Originally a silk fabric typified by uneven yarns in the filling, resulting in an interesting slubbed or nubbed texture. Now made in rayon extensively. Plain weave. Used for sportswear, women's summer suits, pajamas, robes.

**Sharkskin.** Originally a two-color worsted suiting in various weaves, with basket-weave effects most common. Plain, twill, and basic weave variations. (1) Sharkskin suiting is now also made in spun rayon and wool blends, for men's and women's suits. (2) Term also used to describe a well-known rayon sports fabric typified by heavy, semicrisp texture. Used for men's and women's sportswear, summer suits.

**Shepherd's check.** Fabrics having small, even checks. Can be made in wool, rayon, or blends. Usually twill weave. Used for sportswear, women's suits, dresses.

**Surah.** Soft, flexible, lightweight, lustrous twill-weave fabric. Now made in rayon. Used for sports dresses, tailored dresses, blouses, mufflers, ties.

**Taffeta.** A plain, closely woven, smooth crisp fabric. Rayon is used most extensively in modern taffetas. The warp and the filling are of the same or nearly the same yarn size. Plain weave. Used for dresses, children's wear, trimmings, linings, millinery, hangings, draperies, bedspreads, comfortables, lamp shades. *Faille taffeta* has a pronounced crosswise rib. *Pigment taffeta* is made of dull or pigmented yarns. *Tissue taffeta* is of very light weight.

**Tartan.** Originally, Scotch plaids in woolens or worsteds in the distinctive designs and colors of Highland clans. Now also made in spun rayon. Used for children's wear in particular; also women's sportswear.

**Tricot.** Correct name for jersey cloth. Most important of warp-knit fabrics. On the right side, it appears like rib knitting; on the wrong side, the ribs run crosswise. Used for underwear, dress fabrics, sportswear, bathing suits, gloves.

**Tricotine.** Originally, worsted dress goods resembling gabardine but woven with a double twill. Now also made in spun-rayon-and-wool blends. Twill weave. Used for women's suits, coats.

**Triple sheer.** Term in common usage describing a tightly woven sheer fabric with a fine, flat surface. Almost opaque.

**Tweed.** Originally an all-wool homespun made in Scotland. Now developed in spun-rayon-and-wool blends. A roughish fabric with wiry, somewhat hairy texture, casual or sportslike in appearance. In mixtures, nubbed, and slubbed effects. Plain, twill, herringbone twill, or novelty weaves. Used for coats, suits, dresses.

**Velour.** A woven fabric napped on one side. Originally made in wool. Now also made in spun-rayon-and-wool blends. Plain or satin weave. Used for women's coats, draperies, upholstery.

**Velvet.** Broad and inclusive term covering almost all warp-pile fabrics except plush, chenille, terry, velveteen, and corduroy. Velvets are woven double, face to face, and cut apart while still on the loom. *Chiffon velvet* is of light weight. *Lyons velvet* is the name given stiff velvets. *Panne velvet* refers to the finish on lightweight velvet; the pile is laid flat in one direction. *Transparent velvet* is a very lightweight velvet with rayon back and rayon pile. Variation of plain weave. Used for evening wear, formal daytime fashions, negligees, draperies.

**Velveteen.** A fabric with short pile resembling velvet but woven single. Usually made in cotton. Can be made in rayon. Variation of plain weave. Used for women's wear, children's wear, draperies, bedspreads.

**Voile.** A light, transparent fabric similar to mousseline but softer and more clinging. Plain weave. Used for dresses, curtains.

**Whipcord.** A twill fabric with pronounced diagonals. Twill weave. Used for riding habits, uniforms, sportswear.

*Test yourself on this chapter by answering these questions:*

1. How do the qualities of rayon compare with those of natural fibers? Give examples.
2. Discuss the early history of rayon.
3. How does the rayon process imitate the work of the silkworm?
4. What are multifilament yarns?
5. What is the source of rayon? How is the material made into a fiber?
6. What is the difference between regenerated and nonregenerated rayons?
7. Why is rayon considered the youngest of the fibers?
8. How many methods are known for making rayons?
9. What is the essential difference in the ingredients of each type of rayon?
10. What is spun rayon? Why would spun rayon resemble wool fabrics?
11. How do viscose, cuprammonium, and acetate compare as to absorbency? Warmth?
12. What are high-tenacity yarns?
13. Describe three by-products of any of the rayon processes.
14. Discuss crease resistance in rayons and compare with other fibers.
15. Discuss delustering as it pertains to rayon.

## Suggested Readings

American Viscose Corporation, *Rayon Fabrics.*
Eastman Acetate, *Story of Eastman Acetate.*
Hess, K. P., *Textile Fibers and Their Use,* Chapter 6, Section 2.
Mauersberger, H. R., and Schwarz, E. W. K., *Rayon and Staple Fiber Handbook.*
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 8.
Small, C. P., *How to Know Textiles,* Chapter 17.
Wingate, I. B., *Textile Fabrics,* Chapter 6.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 11.

## CHAPTER XIII

# NEW NONCELLULOSE MAN-MADE FIBERS

Improved yarns are constantly being produced from cellulose bases by the various rayon processes. Chemists, however, have not been satisfied with this one source for synthetic textile fibers and have experimented with mineral sources. Nylon was the first important man-made textile fiber to be made wholly from mineral raw materials.

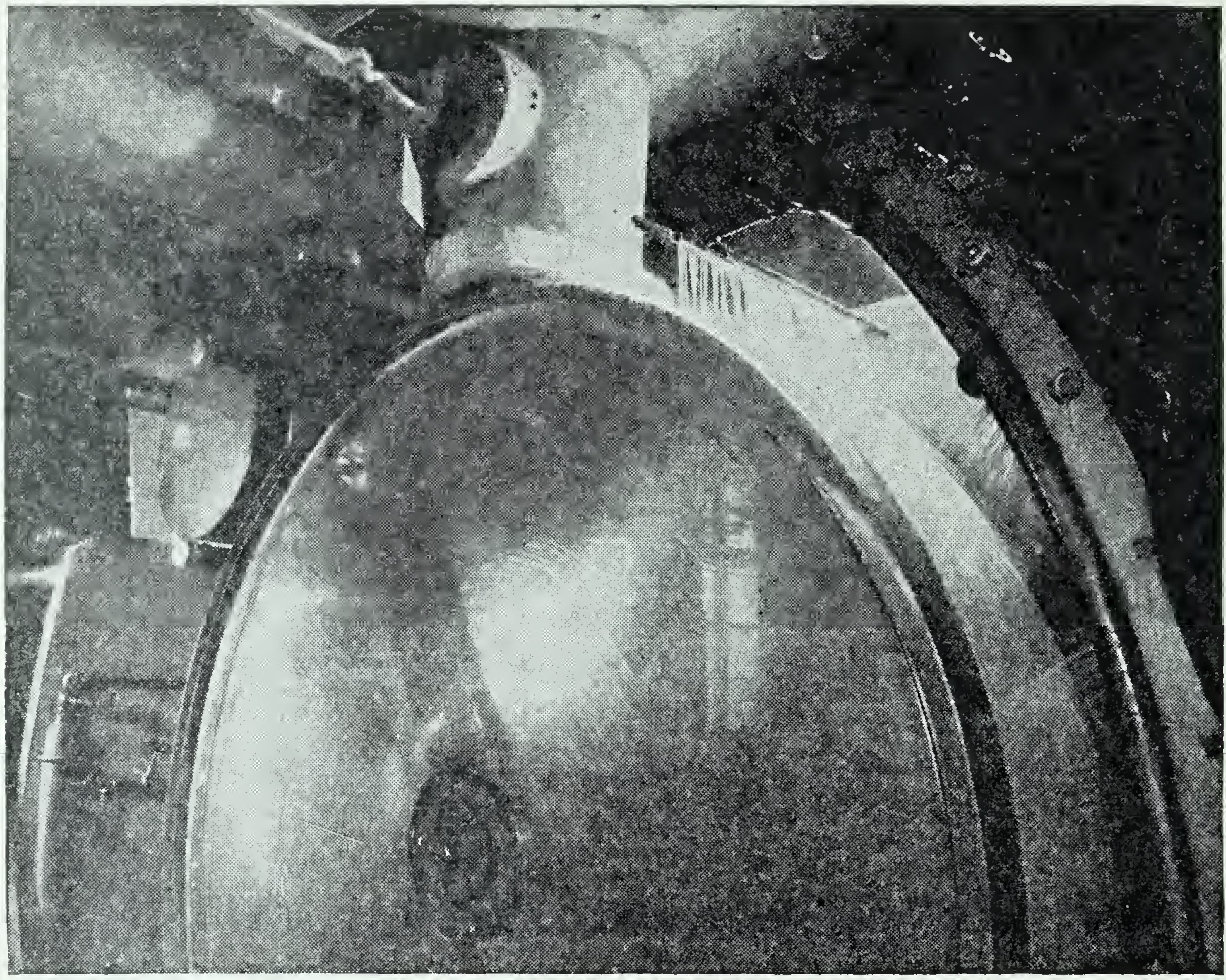
Experimentation with other mineral bases has produced vinyon, fiberglas, and saran. Protein bases have yielded casein fiber—represented by aralac—and soybean fiber. Rubber is combined with any of the major fibers to produce permanent elastic yarns.

In general, this research has been greatly advanced because the sources of natural fibers, particularly silk, were cut off by war conditions. But the textile industry is always interested in producing economical fabrics that will have, if possible, the qualities inherent in the natural fibers.

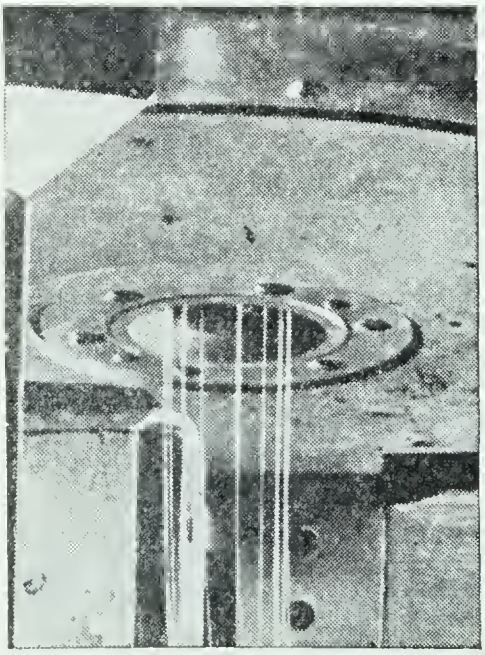
Nylon filament as seen under the microscope.

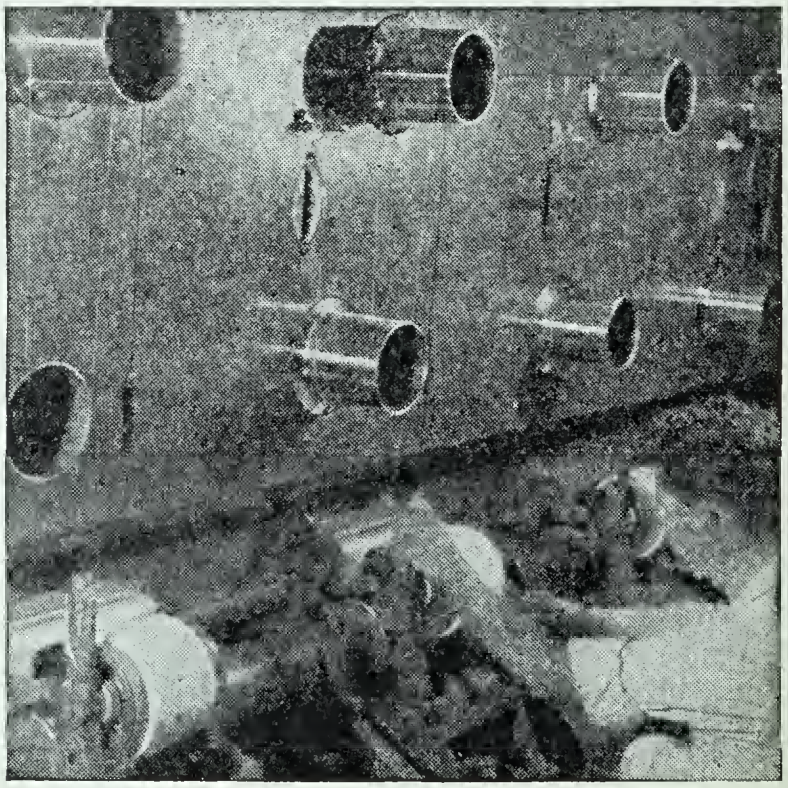
**Nylon.** Nylon differs totally from rayon, in that it is of a noncellulose base, and has unique properties not inherent in rayon. It is made from coal, air, and water: that is, the elements, carbon, oxygen, hydrogen, and nitrogen. Nylon was first introduced as bristles; and in monofilament or single-strand form it is still used in brushes of all kinds. In flake form, melted and applied as a coating, nylon is especially suitable for electrical insulation.

Its qualities of strength and elasticity increased its uses, and nylon soon became well known to the consumer in the form of hosiery. Nylon contributes more of the qualities of silk to hosiery than did the first artificial silks; most consumers prefer nylon to pure silk because it



*Above:* Nylon's first bath. Molten polymer, pressed out on this huge casting wheel, is sprayed with water and solidifies into a strip resembling ivory. *Left below:* The birth of nylon filaments. From tiny holes in this spinneret, fine filaments of nylon are pressed out. The filaments shown here will be wound together to form nylon yarn. *Right below:* After the fine nylon filaments are brought together, the yarn is wound on bobbins.





wears better and longer. Nylon did not reduce the cost of hosiery, however.

At the beginning of World War II, nylon was still in experimental stages as a general clothing fabric. But its development as a substitute for silk has already earned a definite place for nylon, with interesting future possibilities, among the man-made fibers.

*Spinning Process.* The mineral elements from which nylon is made are combined to form a nylon salt. This is changed into a liquid, which is then solidified and chipped into flakes. The flakes are melted to produce a viscous spinning solution. The nylon filament is produced by methods similar to those by which other man-made fibers are produced. The spinning solution passes through spinnerets and is drawn out and twisted into a filament, which is coated with an emulsion and heated to set the twist.

*Strength.* Nylon has extremely high tensile strength. When dry, it is stronger than silk. When wet, nylon loses only about 12 per cent of its original strength, which is completely regained when dry. Because of its strength, nylon is used for fishlines, racket strings, cords, glider tow ropes, parachutes, and for surgical sutures. Nylon does not deteriorate with age.

*Elasticity.* Both in multifilament yarn, which is 30 to 40 denier with 7 to 69 filaments, and in monofilament form, nylon possesses unusual elasticity, which contributes to its durability. For example, when the yarn is stretched to 16 per cent of its length, its elastic recovery is about 91 per cent; at 8 per cent stretch, recovery is 100 per cent.

*Absorbency.* Nylon has lower absorbency than silk; the total water absorbency of nylon is 3.5 per cent of its weight, less than any other fiber. This water-resistant quality is an advantage in bristles for toothbrushes. Hygienically, it is a disadvantage in hosiery, because a low degree of absorbency does not allow a textile to absorb perspiration to the extent desired when worn next to the skin.

*Heat Conductivity.* Although nylon resembles silk in certain respects, it does not possess the insulative properties of silk or of wool. Nylon is an unusually cool fabric, so lacking in the warmth-giving quality that it is more suitable for summer apparel than for winter use.

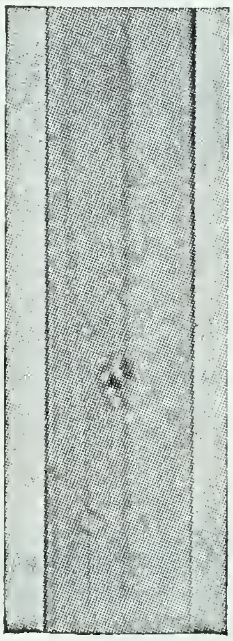
*Cleanliness and Washability.* Dirt particles do not cling to nylon because of its smooth surface. It can be easily washed, no special precautions being necessary. Nylon's fast-drying quality, which is the result of water resistance, is of great advantage; nylon dries thoroughly overnight. Nylon can be ironed freely as it withstands heat up to 470 degrees Fahrenheit. It melts at about 480 degrees.

*Affinity to Dye.* Nylon has a marked affinity for most of the dyestuffs used for silk, wool, and acetate rayon. Sunlight has virtually no effect on nylon.

*Resistance to Acids and Alkalies.* Alkalies have no effect on nylon. It is resistant to weak acids but is affected adversely by strong acids; for example, if boiled in a 5 per cent solution of hydrochloric acid, nylon becomes brittle. Nylon is soluble in phenol cresol, xylenol, and formic acid. When immersed in acetone, it is unaffected.

*Mothproof and Mildewproof.* Moths do not attack nylon, and it is also wholly resistant to mildew.

*Burning Test.* The burning test shows that nylon has a very low burning rate; the flame quickly dies out. The ash is hard, like acetate, but is either white or light tan in color; the ash of acetate is black. The odor of the ash is somewhat like that of an animal fiber, but more definitely like burned sealing wax.



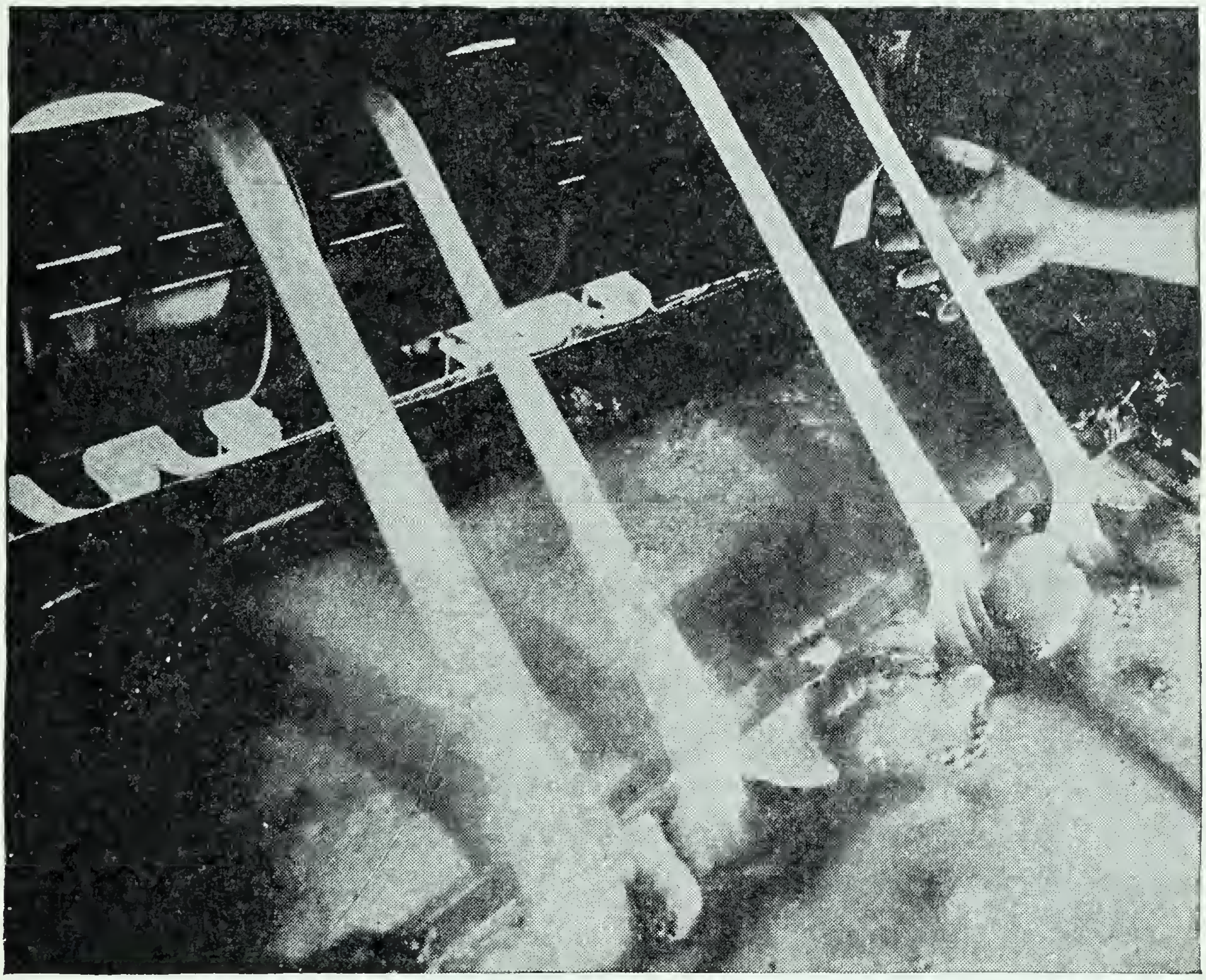
Vinyon filament as seen under the microscope.

**Vinyon.** Vinyon is another noncellulose man-made fiber. It is made from vinyl resin, which is derived from natural gas (or coal), salt, water, and air. In the form of a dry powder, the vinyl resin is dispersed in acetone. It is then filtered and deaerated by allowing it to stand for two days. The spinning process is somewhat similar to that of other man-made fibers. After extrusion of the filament, which is twisted while wet, the yarn is stretched to about 140 per cent of its original length, and is permanently set in this form by immersion for several hours at 150 degrees Fahrenheit. It is then wound in skeins or on cones.

As a result of this stretching process, the strength of vinyon yarn is tripled, and it has a degree of elasticity that compares favorably with silk and wool. This quality makes it suitable for hosiery. When wet, vinyon does not lose its strength.

This fiber is made in two forms: continuous filament and short staple. The short-staple form is mixed with cotton or wool for use in felt and for fabrics in which creases or folds must be retained. When first produced, the continuous-filament yarn was made in denier sizes of 60, 120, and 180, being composed of 46, 92, and 138 filaments, respectively.

Vinyon yarn is not affected by moths, mildew, or age; it does not support combustion, and can be softened only at a heat of about 290 degrees Fahrenheit. The effect of sunlight is very slight. The degree of water absorbency is extremely low. Vinyon is not affected by alkalies, acids, or almost any other chemical except acetone and carbon tetrachloride.



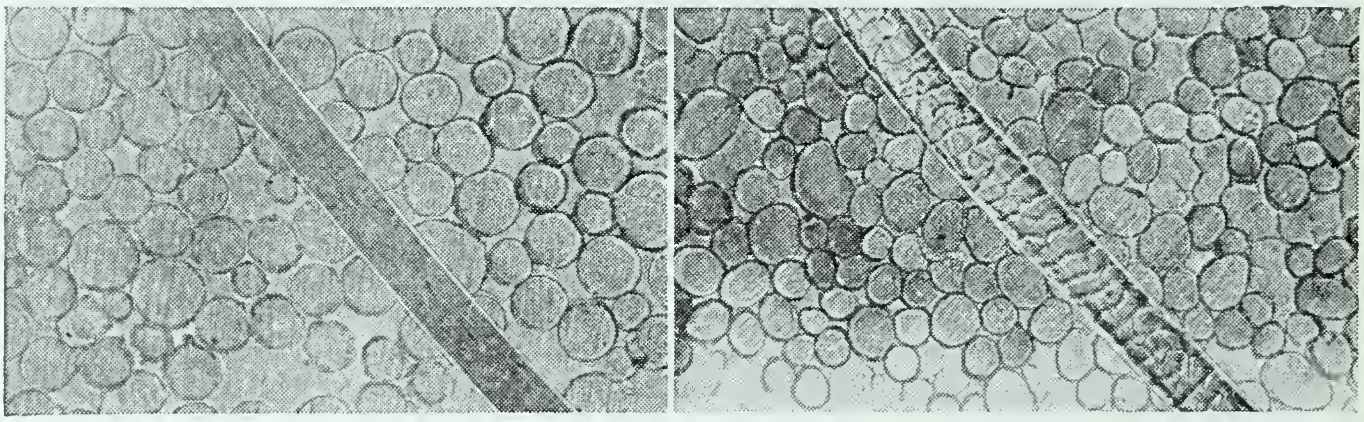
Four spinnerets concealed under the foam produce taffylike strips of aralac fiber.

With these properties, vinyon is especially suitable for acid- and alkali-resistant clothing, industrial filter fabrics, fireproof awnings and curtains, waterproof clothing, shower curtains, bathing suits, electric insulation, and protective pipe coverings. Vinyon gives promise of adaptation to general textile uses because of its unique properties.

**Casein Fiber.** Casein fiber is a protein substance produced by precipitating casein from skim milk and dissolving it in an alkaline solution, which is aged and then spun through spinnerets into an acid bath.

This fiber was originally made in Italy under the name of *lanital* and was used there as a substitute for wool. Other countries, including England, Germany, and Japan, have developed similar casein fibers under various trade names.

In the United States, the casein fiber made from milk protein was named *aralac*. (Other raw materials may be used, such as the protein from the soybean.) Milk casein constitutes approximately 3 per cent by volume of the skim milk that is left from whole milk after the butter fat or cream has been taken off. After the casein has been extracted, it is dried and ground, then poured into a mixer and passed into vats where chemicals are added.



Aralac filament with its cross-section view under the microscope (at left) is here shown for comparison with wool fiber and its cross-section view (at right).

Heating transforms the liquid into a viscous emulsion, which is forced through spinnerets under pressure, similar to the process for other man-made fibers. Thousands of strands of continuous filament emerge. These strands are squeezed under pressure in a conditioner in order to extract the manufacturing chemicals.

The resultant soft, resilient fiber is cut into short staple from ½ inch to 6 inches in length and is combined with any of the natural or synthetic fibers. With the exception of its use as interlining, aralac is always combined with other fibers because of its low tensile strength. Used in blends with cotton, wool, or rayon, aralac makes economical fabrics for suitings, interlinings, dress goods, and blankets.

Chemically, aralac is similar to wool, except that it contains no sulphur; it can be produced with a crimp, which makes it resemble wool. Aralac also has the same qualities of high resiliency, nonconductivity, and water absorbency, as well as a high affinity for any of the dyes used for wool. Unlike wool, it is resistant to moths but is attacked by mildew.

The following table compares the chemical composition of aralac and wool:

| | *Aralac* | *Wool* |
|---|---|---|
| Carbon | 51.23 | 49.25 |
| Hydrogen | 7.01 | 7.57 |
| Oxygen | 26.93 | 23.66 |
| Nitrogen | 13.29 | 15.86 |
| Sulphur | .72 | 3.66 |
| Phosphorus | .82 | .... |

Like wool, aralac is not affected by weak acids. Strong acids decompose it. Weak alkalies at low temperature have no adverse effect, but at high temperature they cause a material loss in tensile strength.

*Tests for Aralac.* To determine the presence of aralac in a fabric, examine with the microscope. Allow a 50 per cent sulphuric acid solution to flow around the fibers on a glass slide that has a cover glass. If aralac is present, the microscope will show a formation of diamond-shaped figures formed by the stress in the fiber when it is partially softened by the acid. The figures disappear completely as the stress is released by complete softening of the fiber.

Pure aralac yarn shows marked loss of strength when wet.

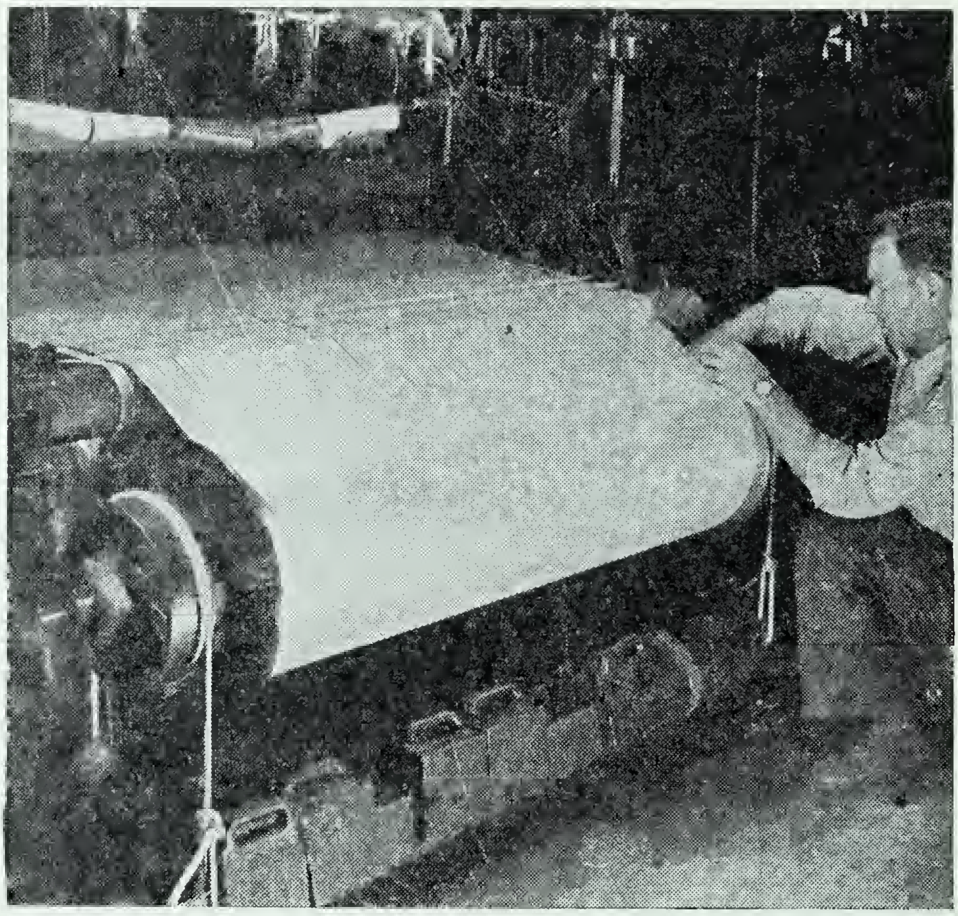
Appearance of aralac filament under the microscope when subjected to the sulphuric identification test.

**Soybean Fiber.** The fiber produced from the soybean is also of a protein base. Soybean fiber resembles wool in resiliency and feel; it is insulative, and has a tensile strength about 80 per cent that of wool. It excels wool in resistance to alkalies.

The soybeans are crushed into a meal, which is treated with a saline solution to extract the protein. This extract is subsequently changed into a viscous solution, which is spun into fiber by methods similar to those used to produce other synthetic fibers. The fibers are in a fluffy mass and resemble scoured wool. The tensile strength of soybean fiber is a little less than that of wool. Its strength is not affected by moisture.

Some of the potential uses of soybean fiber include blending with wool to give a soft quality to upholstery, suitings, and felt.

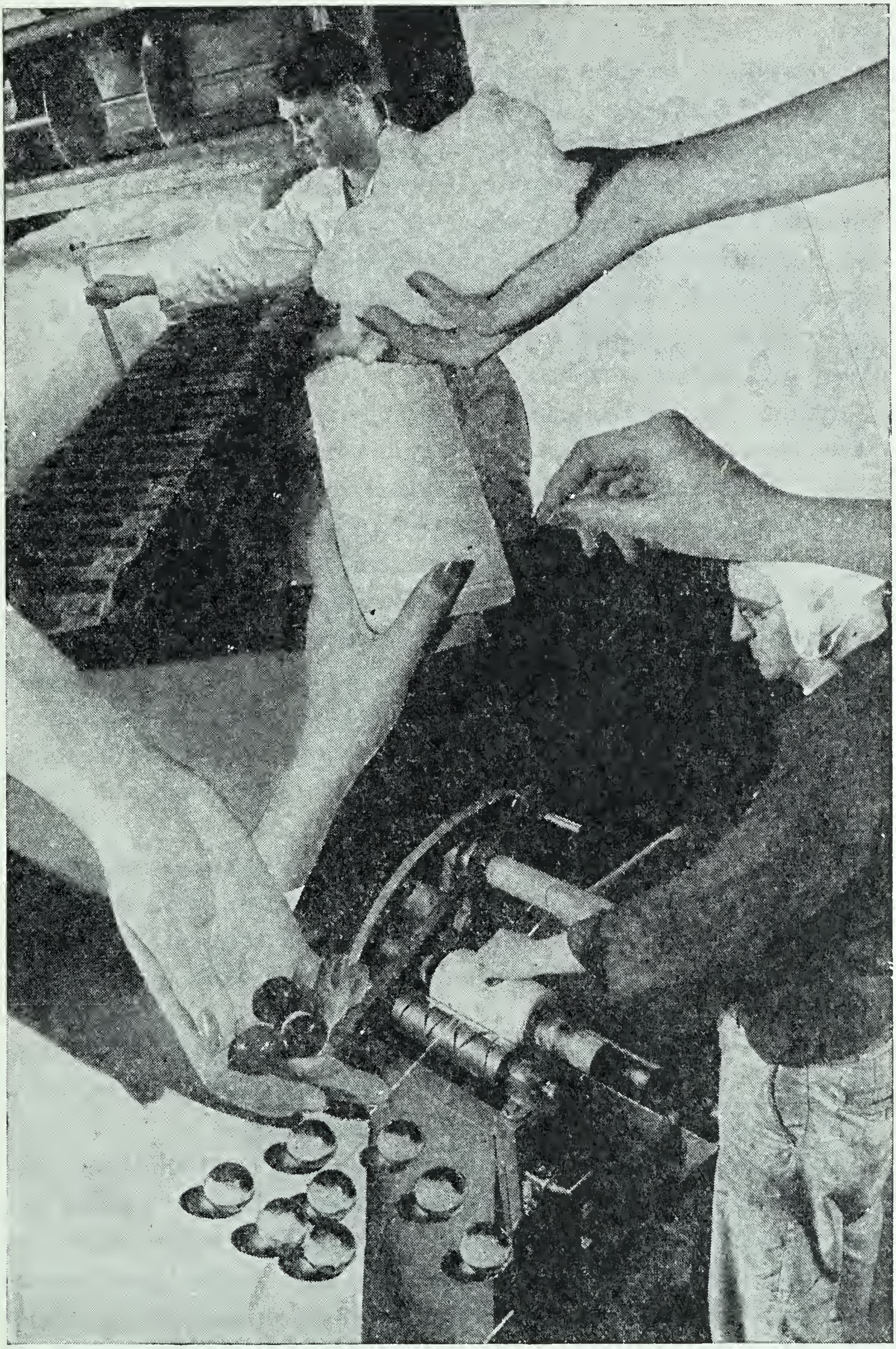
**Fiberglas.** Textile fibers and yarns are produced from glass, which, when drawn fine enough, can be woven into strong, flexible fabrics.



Fiberglas yarns being wound on a warp beam preparatory to weaving an all-glass fabric.

The raw materials that are used to make ordinary glass are refined and shaped into glass marbles. These marbles are remelted and formed into more than a hundred glass filaments, which are simultaneously attenuated into a single yarn of minute diameter. Glass yarns have been produced as fine as 100s cotton count.

Short-staple glass fibers, ranging from 8 to 15 inches in length, are produced by striking the streams of molten glass with jets of high-pressure air or steam. This process separates the filament where required, and seals the ends of the short staple. Short-staple glass yarns have a fuzzy surface, but the continuous filament produces smooth yarns.



Marbles of purified glass (lower left) are reduced to spun-glass fiber (upper left). The fiber is spun into yarn and reeled on bobbins (center) ready for the next step in constructing all-glass fabric.

Fiberglas is resistant to most chemicals and is insoluble in organic solvents. It is affected only by hydrochloric and phosphoric acids, and by weak, hot solutions or strong, cold solutions of alkalies.

Fiberglas is used for fireproof clothing and draperies, for electrical insulation, and for soundproofing. It is noninflammable, nonabsorbent, mothproof, mildewproof, and resistant to sunlight; it does not deteriorate with age. These qualities make fiberglas a very hygienic fabric. Home-furnishing products include bedspreads, curtains, tablecloths, and shower curtains.

**Saran.** In the production of saran, another resinlike substance, petroleum and salt are first treated to produce ethylene and chlorine, which, when combined, form vinylidene chloride. These are chemically processed with vinyl chloride to form saran synthetic resin. The resin is melted, formed into monofilament yarn or ribbons, stretched, and subsequently set with or without heating.

Saran is particularly suitable where tensile strength, elongation, and resistance to chemicals and solvents, abrasion, flame, light, moths, and mildew are important. These qualities are used to advantage in the manufacture of filter cloths, window screens, upholstery, draperies, wall coverings, suspenders, rope, cord, tennis rackets, and seat covers in transportation vehicles.

**Lastex.** Lastex yarns combine rubber with cotton, wool, silk, or rayon yarns to produce a permanently elastic yarn that is used for a variety of purposes. Latex composes the rubber core, and any of the textile yarns may be wound around it, forming a filament whose surface is fully vulcanized.

Lastex yarn may be used as warp or filling; the woven fabric stretches in the direction of the lastex yarn. If used for both warp and filling, the fabric is stretchable in both directions.

Lastex yarns are used extensively in fabrics for foundation garments, abdominal bands, underwear, bathing suits, and various apparel in which snug fit is essential. These yarns can be made fine enough for such sheer fabrics as batiste and lace. Lastex garments are porous and therefore hygienic. Because of their comfort, they are especially suited for sportswear. They do not lose elasticity readily, and endure dry cleaning, washing, and the heat of a moderate iron without shrinking or stretching out of shape.

*Test yourself on this chapter by answering these questions:*

1. What are the characteristics of nylon? Name disadvantages, if any.
2. Name some uses for nylon.
3. What are the basic materials from which nylon is made?
4. How can nylon be recognized by the burning test?
5. What man-made fibers have the characteristics of wool?
6. What man-made fibers have a protein base?
7. What are the qualities of fiberglas? How would you use it in your home?
8. Which man-made textile fiber interests you the most? Tell why, describing the fiber briefly.
9. Why is aralac fiber usually combined with other fibers?
10. Why is nylon suitable for parachute fabric?
11. Why is vinyon regarded as a close competitor of nylon?
12. What new noncellulose man-made fibers have fireproof properties?
13. List the basic properties of aralac and show the effect of each property on the finished goods.
14. Why is fiberglas fabric not used for men's outer apparel?
15. Why is fiberglas fabric used as a stuffer for men's ties?

## Suggested Readings

Dooley, W. H., *Textiles,* Chapter 34.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 12.

## CHAPTER XIV

# MINOR NATURAL FIBERS: USEFUL AND ECONOMICAL

The textile industry uses other vegetable and mineral fibers in addition to those already studied. Each has its field of usefulness. Some have qualities that make them suitable for purposes that none of the major fibers could fulfill economically; others bear enough resemblance to major fibers to be used as acceptable substitutes or even adulterants, so long as the finished goods fulfill the purpose for which they are intended and the selling price is in line with the value of the product.

**Jute.** Jute is a fiber obtained from a tall plant of the same name. It is grown throughout tropical Asia, chiefly in India, for commercial uses. The plant is easy to cultivate and harvest; the fiber is obtained by retting, similarly to flax. The fine, silklike fiber is easy to spin; but it is not durable, as it deteriorates rapidly when exposed to moisture.

Jute is the cheapest textile fiber; it is used in great quantities. Because of its lack of strength, jute is difficult to bleach and can never be made pure white. It can be converted into a wool-like fiber by treatment with a strong caustic soda.

Jute is often used as an adulterant with other fibers, but can be easily recognized when tested for its marked sensitivity to mineral acids. Concentrated mineral acids readily dissolve jute; dilute mineral acids rot it quickly. It is especially weak in salt water.

Jute is used as a substitute for hemp, as binding threads for carpets and rugs, as a filler with other fibers, and as a linoleum base. It is made into coarse, cheap fabrics, such as novelty dress goods and heavy cotton bagging.

**Kapok.** Kapok is a fine, white, hairlike fiber obtained from the seed capsules of plants and trees grown in Java, Borneo, Sumatra, and Central America. It is sometimes called "silk cotton" because its luster is almost equal to that of silk. Kapok resembles cotton in general appearance but, unlike cotton, is always of short staple—less than 1 inch.

The smooth, weak texture of kapok prevents its being spun into yarn, but it is felted for use in mattresses, cushions, upholstered furniture, and life preservers. Kapok is buoyant, but with continued use has a tendency to mat and become lumpy. This condition can be improved if bedding articles in which kapok has been used are aired and put in the sun at frequent intervals.

Kapok is resistant to vermin and is especially resistant to moisture, drying quickly when wet; it is adaptable for articles that are constantly exposed to moisture. Kapok is also used for soundproofing in airplanes and for insulating material in refrigerator cars and trucks.

Under the microscope, kapok can be easily distinguished from cotton, as it appears to be a hollow circular tube with very thin walls and frequent folds but no twist.

**Ramie.** Ramie is a woody fiber resembling flax. It is obtained from a tall shrub grown in southeastern Asia, China, Japan, and southern Europe. Ramie is also known as rhea and as China grass.

The fiber is stiff, more brittle than linen, and highly lustrous. It can be bleached to extreme whiteness. Ramie lends itself to general processing for textile yarns, but its retting operation is difficult and costly, making the fiber unprofitable for general use. When combed, ramie is half the weight of linen, but much stronger, coarser, and more absorbent. It has permanent luster and good affinity for dyes; it is affected little by moisture.

Ramie is used as filling yarn in mixed woolen fabrics, as adulteration with silk fibers, and as a substitute for flax. The China-grass cloth used by the Chinese is made of ramie. This fiber is also useful for rope, twine, and nets.

**Hemp.** Some thirty varieties of hemp, another tall plant with a woody fiber, are grown in nearly all the temperate and tropical countries of the world. All these varieties resemble one another in general appearance and properties; but the only kinds having commercial value are those having fibers of high tensile strength, fineness, and high luster. Hemp must pass through a retting process and subsequent manufacturing operations similar to those used for flax. It resembles flax closely, and its fiber is easily mistaken for linen.

Hemp is harsh and stiff, and cannot be bleached without harm to the fiber. As hemp is not pliable and elastic, it cannot be woven into fine fabrics. Manila hemp, which is very strong, fine, white, and lustrous, though brittle, is adaptable for the weaving of coarse fabrics.

Hemp is durable and is used in carpet and rug manufacturing. It is especially suitable for ship cordage and sailcloth as it is not weakened or rotted by water. Central American hemp is chiefly used for cordage.

**Sisal.** Sisal is a fiber obtained from the leaves of a plant that resembles cactus. It is grown in Central America, the West Indies, and Florida. The best supply is produced in Yucatan, where it is known as henequen. The smooth, straight fiber is light yellow in color.

Sisal is used for the better grades of rope, for twine, and for the bristles of inexpensive brushes. It is used as a substitute for horsehair in upholstering. Sisal may be mixed with hemp, but it should not be used for ship cordage because it disintegrates in salt water.

**Coir.** A coarse brown fiber called coir is obtained from the husk of the coconut. It is stiff but elastic. Because of its resemblance to horsehair, it is used for stuffing upholstered furniture. Coir is also suitable for cordage, sailcloth, and coarse mattings.

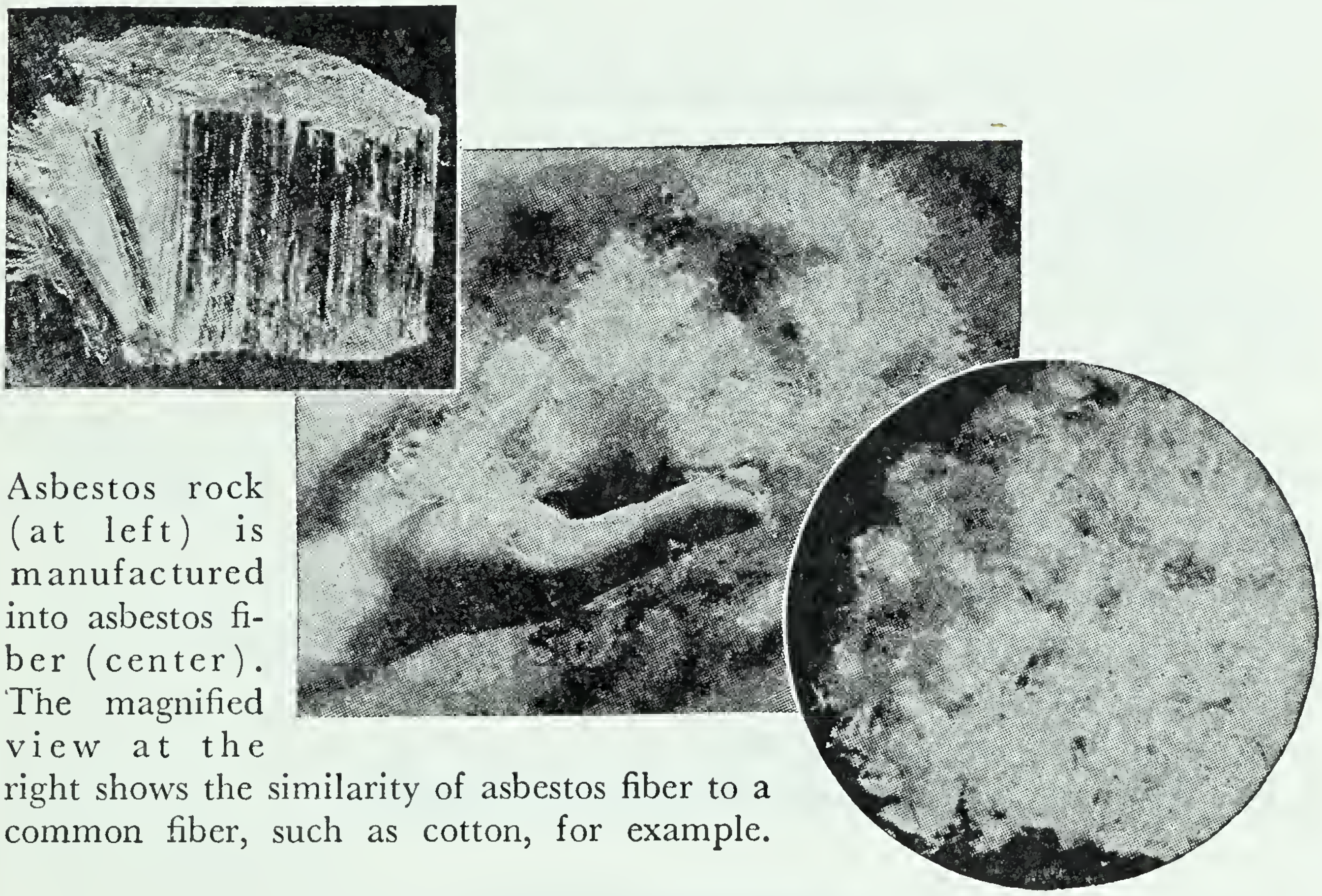
**Pina.** Pina, or pineapple fiber, is obtained from the large leaves of the pineapple plant grown in tropical countries. The fiber is white and especially soft and lustrous. In the Philippine Islands, it is woven into pina cloth, which is soft, durable, and resistant to moisture. Pina is also used in making coarse grass cloth and for mats, bags, and clothing.

**Metal Threads and Tinsel.** Any of the ductile metals, such as gold, silver, copper, and even the cheaper alloys, can be drawn out into fine filaments. These are used to ornament fabrics. Metallic threads are made round or flat and may be twisted with any of the major textile fibers. Sometimes base metals are drawn out as fine wires and are covered with the more costly metals. Thus, silver thread may have a core of copper covered with a layer of silver; similarly, gold thread may consist of gold-plated copper wire.

When metal threads are elongated to an extremely fine diameter, they are usually known as tinsel; among the many types are fine tinsel lamé, tinsel laminette, tinsel bullion, and tinsel braid.

Metal threads are used in the millinery trade and as decoration in the form of fringe and braid, as well as for woven and embroidered patterns on tapestries, brocades, and upholstery fabrics. Fine tinsels are used in fabrics for evening dresses, handbags, and ecclesiastical robes.

**Asbestos.** Asbestos is a mineral fiber obtained from varieties of rocks found in Italy, South America, and Canada. It is a fibrous form of silicate of magnesium and calcium, containing iron, aluminum, and other minerals. The soft, long, glossy white fibers are pressed into sheets, and the best quality can be spun into yarn. Chrysolite asbestos is the most valuable for the latter purpose, as it has a fine, long staple that has strength and flexibility. Asbestos yarns are always made as ply yarns in order to increase their tensile strength.



Asbestos rock (at left) is manufactured into asbestos fiber (center). The magnified view at the right shows the similarity of asbestos fiber to a common fiber, such as cotton, for example.

Asbestos will not burn, but it will melt at a sufficiently high temperature. It is acidproof and rustproof. Asbestos is made into fireproof materials of many types—theater curtains, draperies, shingles, tiles, auto brake lining, andiron holders, and partitions. It is spun around copper wire and wrapped around pipes and joints of high-pressure steam engines. Inferior grades are used for soundproofing purposes.

Although asbestos has always been used when fighting fire, the challenging conditions of World War II greatly advanced the types of fire-fighting suits and fire-resistant fabrics for which this useful mineral fiber had already become noted.

**Slag Wool.** Molten lead or iron can be processed into the form of fibers, which are used as felt and packing material for insulative purposes in the building trades. This by-product of the blast furnace is light in weight; it is fireproof, heatproof, soundproof, verminproof, moistureproof, and rotproof.

*Test yourself on this chapter by answering these questions:*

1. For what purposes are the minor natural fibers generally used?
2. Name five minor vegetable fibers and give one use for each.
3. How are metal threads and tinsel made? For what purposes are they used?
4. What type of fiber is asbestos? Describe its qualities and how they are used.
5. What by-product of the steel industry is used as insulative material? Name four of its qualities.
6. Why is jute never available in a pure-white color?
7. Why is kapok always felted, never woven?
8. How does kapok differ from cotton?
9. Compare ramie with linen.
10. Why is hemp especially suitable for sailcloth?

## Suggested Readings

Bray, H. A., *Textile Fibers, Yarns, and Fabrics,* Chapters 4, 5.
Dooley, W. H., *Textiles,* Chapter 20.
Hess, K. P., *Textile Fibers and Their Use,* pp. 176–186.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 10.

## CHAPTER XV

# KNITTING AND MINOR CLOTH CONSTRUCTIONS

Up to this point, weaving is the only method of cloth construction that has been described. The sketch on page 3, however, shows that cloth is constructed by processes other than weaving; that is, by knitting, felting, braiding, and netting. Of these four, knitting comes second in importance to weaving. Although the knitting construction is not so widely used for general fabrics as weaving, it possesses qualities that make it preferable for certain garments—for instance, for such important articles as hosiery, sweaters, and underwear.

**History of Knitting.** Hand knitting was probably an early invention of man, but the art seems to have been perfected in western Europe in the fifteenth century. The word "cnyttan" was first mentioned in English literature in 1492. Hand knitting spread rapidly throughout Europe within a few generations. Primitive needles of bone or wood were first used, producing a coarse mesh. The Spaniards began to use steel needles, which produced a closer mesh and a more evenly knit fabric.

In 1589, the Reverend William Lee, an Englishman, invented the first knitting machine, which knit eight loops to an inch of width. As this construction was too coarse a mesh, he improved the machine so that it was possible to knit twenty loops to the inch. Today, the average is twenty-eight loops, and the modern knitting machine still operates on the same general principles established by William Lee.

**Knitted Construction Compared with Weaving.** Knitted cloth is constructed with a single yarn that is formed into interlocking loops by the use of wires or needles. The loops may be either loosely or closely constructed, according to the purpose of the fabric. Crocheting is knitting in its simplest form. A chain of loops is produced from a single thread by means of a hook.

The interlocking loops of the knitted construction permit the fabric to stretch in any direction, even if low-grade yarn having little elasticity or yarn that lacks natural elasticity is used.

Woven fabrics are produced by the interlacing of two or more yarns; this method of construction does not allow the fabric to stretch to any marked degree. If a certain amount of stretching is necessary, woven cloth must be cut on the bias, that is, in a diagonal direction; but even then the cloth can be stretched only in the direction of the diagonal cutting.

This advantage of stretchability that knitted cloth possesses is an important consideration where fit and comfort are concerned. Knitted fabrics also give warmth because of the insulative air pockets contained in this type of construction. Knitted fabrics are very absorbent and light in weight, and do not wrinkle easily; it is not always necessary to iron them after washing. These qualities make the knitted construction desirable for underwear and especially for sportswear.

Certain kinds of knitted cloth have one serious disadvantage: if one of the loops breaks, a hole is made, which starts a run. This disadvantage can be eliminated by variation in the stitch, which protects the cloth from raveling if any single stitch is broken. This feature is not extensively used.

*Evaluating Construction of Knitted Cloth.* It will be recalled that cloth count (the number of threads per square inch) was used to evaluate the construction of woven fabrics. The construction of knitted fabrics is determined by the number of stitches or loops that can be counted in any square inch.

When the interlocking loops run lengthwise, each row is called a *wale.* A wale corresponds to the direction of the warp in woven fabrics. When the loops run across the cloth, each row is called a *course.* A course corresponds to the filling or weft. Thus, a knitted cloth having 40 loops or stitches in 1 inch of width, and 50 loops in 1 inch of length, is said to have 40 wales and 50 courses.

**Classification of Knitted Fabrics.** Knitted fabrics are divided into two general classes or types: (1) those produced by weft knitting, where one continuous yarn forms courses across the fabric; (2) those produced by warp knitting, where a series of yarns forms wales in the lengthwise direction of the fabric.

*Weft Knitting.* There are three fundamental stitches in weft knitting: (1) plain knit stitch, (2) purl stitch, (3) rib stitch. Novelty stitches, such as the tuck, the cardigan, and the rack, are merely variations of these three. Weft knitting is the hand method of knitting.

The *plain knit stitch* can be produced flat knit or in tubular form according to the machine used, and is therefore sometimes known as the flat knit or jersey stitch. It is formed by the interlooping of one or more weft threads, and can be identified by *wales on the right side* of the fabric, or by *courses on the underside.* As the fabric will stretch more in width than in length, the plain knit stitch is used for underwear, sweaters, gloves, and especially hosiery.

The *purl stitch* shows *courses on both sides* of the fabric, and both sides are similar. This stitch produces greater lengthwise stretch. It is used for scarves and for various kinds of sweater suits.

The *rib stitch* is a combination of the plain and the purl stitches. It is a slower stitch to produce and requires more yarn. It is characterized by lengthwise rows and is identified by *wales on both sides* of the fabric. The construction makes the fabric more elastic and therefore appropriate for apparel where snugness of fit is essential. The rib stitch is used for knitting the wristbands of sleeves and the waistlines of knitted garments; and for bathing suits, men's undershirts, and men's and children's socks.

*Warp Knitting.* Warp-knit fabrics are of only one type, the flat knit, which produces a flat piece of cloth. They are made on a machine called a chain loom. In warp knitting, a series of yarns is placed side by side on separate needles. Wales are produced in the lengthwise direction of the fabric, forming vertical rows of loops.

The most common stitches used in warp-knit fabrics are *tricot* and *milanese*; these are found in glove-silk underwear, fabric gloves, scarves, and materials for foundation garments.

Warp-knit fabrics are less elastic than weft-knit, but they are stronger, firmer, and more resistant to snag; they do not run or ravel when a single stitch is broken.

## Felting

Felt differs from woven or knitted cloth in that it requires no interlacing or interlooping yarns. The fibers are interlocked by subjecting them to heat, moisture, and pressure. Felting is a relatively simple, and the least expensive, method of cloth construction. Felt is always made from short-staple fiber.

Wool fibers, hair fibers that have the same properties as wool, and the hair of fur-bearing animals all possess the cohesive or felting property that allows the fibers to be pressed into a compact cloth.

Felt has no warp, filling, or selvage. As it does not have a system of threads, it will not fray or ravel. Being made without twist, felt has little tensile strength and no elasticity; it cannot be draped, but it can be cut or blocked into any shape and will retain that shape unless subjected to undue tension.

Lack of strength limits the uses of felt as a general clothing fabric, but it is especially adaptable for hats. Felt is also suitable for such articles as slippers, shoe insoles, ear muffs, pennants, and table padding. It is used for insulative purposes and for noise absorption. It has various industrial uses.

**Fur Felt.** The short fibers of such fur-bearing animals as the rabbit, muskrat, nutria, and beaver are important in the manufacture of felt for hats. Felt is usually made from a mixture of fibers. The better grade of hat felt contains beaver fibers.

**Wool Felt.** Lower-priced grades are made chiefly from wool felt, which may be easily distinguished from fur felt by its dull appearance, hard feel, and comparatively rough texture. Cotton, kapok, or rayon may be combined with wool. In the most satisfactory grades, however, at least one-half the blend comprises wool, as the wool fiber surpasses all others in the physical quality of cohesiveness that makes this type of cloth construction possible. Short-staple wool fiber, or noil, is used for felt; but the finer the grade of staple used, the stronger will be the felt.

**The Felting Process.** In the process of felting, two carding operations make the fibers parallel and of even thickness. At the end of the operations, the fibers are in the form of a fine web. Several webs may be built up until a sufficient amount of weight or thickness has accumulated. Timing is an important element during these processes, so that the web will not be broken or have weak areas.

The mass, or batt, may then be cut and the edges trimmed to the desired width. Finished felt may vary in thickness from a few thousandths of an inch to 3 inches. Any thickness can be obtained by superimposing batts on one another and felting them together. Batts are usually about 40 yards long and 60 to 90 inches wide; their weights vary from 18 to 50 pounds.

The batts are evenly sprinkled with warm water, passed over a steambox to warm the fibers thoroughly, and then pressed between two rollers. The top roller rests on the batt and, with an oscillating motion, exerts the pressure that, combined with moisture and heat, produces the final felting action.

After the batts have been processed they are allowed to drain and cool off for about twenty-four hours. The timing for each raw material or blend used in the felt is very important. The felt is then dampened with a suitable lubricant, such as a soap and soda combination, for the fulling process, by which it is subjected to a pounding action with hammers. The fulling time varies from five minutes to half an hour. The longer the felt is fulled, the firmer it will be; but this operation cannot be continued too long or the quality of the felt would be spoiled.

Final operations include washing, stiffening, ironing, brushing to raise a nap, and shearing to produce a smooth even surface. Felt may be waterproofed, fireproofed, or mothproofed; it may be dyed against fading, perspiration, cleaning, and washing.

## Braiding or Plaiting

Another form of cloth construction is the diagonal or lengthwise interlacing that is most familiar as the method of braiding or plaiting long hair. Braid is formed on a braiding machine by interlacing three or more strands of yarn so that each strand passes over and under one or more of the others.

This principle of cloth construction is used for making shaped articles, such as straw hats and small rugs; narrow fabrics, such as ribbons and braids for millinery and accessory dress materials; cords and tapes, such as fishlines, shoelaces, wicks, parachute and glider cords, and elastic of various types; and cord coverings for tires, tubing, hose, wires, and cables.

Braids are divided into two types: (1) flat braids, which are in the form of strips or narrow, flat tapes; (2) round braids, which are tubular in form and may be hollow or have a center core of some material. Both types of braiding are produced from any of the textile fibers, as well as from metal threads, tinsel, straw, wire, or leather.

## Netting

Netting is an open-mesh form of cloth construction that is held together by knots at each point where the yarns cross one another. The mesh varies in size and type, and ranges from the very open fish net to the finest and most delicate lace designs.

The open-mesh construction is characteristic of both nets and laces. The true lace construction is always made with a design. Bobbinet, which is a machine-made net, does not have a design, and is therefore not a true lace.

Laces were first made only by hand, and hand laces have always been highly prized as trimming for apparel and as decorative pieces for the home. Unusually beautiful and intricately designed laces are retained in families as heirlooms and are displayed in museums as representative of the handicraft of nations of the world. Real laces, such as needlepoint, bobbin, pillow, darned, and crocheted, are now duplicated so expertly by machine that the average consumer is not able to determine whether a lace is machine-made or handmade.

Linen yarns are generally used for expensive laces; but cotton, silk, or rayon yarns are used for various qualities and types. Lace may be made by knotting or by looping, braiding, stitching, or twisting.

*Test yourself on this chapter by answering these questions:*

1. How does the construction of knitted fabrics differ from that of woven fabrics?
2. What is the chief advantage gained by the knitted construction? For what types of clothing is it preferable?
3. Why is a knitted fabric always a warm fabric?
4. What is a disadvantage of the knitted construction? Can it be eliminated? If so, how?
5. How would you evaluate the construction of knitted fabrics?
6. Describe the two types of knitted fabrics. Name a finished product of each type.

7. Describe the felting process.
8. For what purposes is the braided construction used?
9. Why are at least three strands required in braiding?
10. Why is braiding confined to the production of shaped articles?
11. How does felt differ from other cloth construction?
12. Why is wool preferred to fur in making felt cloth?
13. Why are fur fibers used in the production of expensive felt hats?
14. How is felt used for industrial purposes?
15. How does net differ from woven cloth?

## Suggested Readings

Bray, H. A., *Textile Fibers, Yarns, and Fabrics,* pp. 118–135.
Caplin, J., *Lace Book.*
Dooley, W. H., *Textiles,* Chapters 6, 21, 22.
Miller, M. C., *Principles of Knitting.*
Page, E., *Lace Making.*
Small, C. P., *How to Know Textiles,* Chapters 4, 5.
Wingate, I. B., *Textile Fabrics,* Chapter 11.

## CHAPTER XVI

# HOSIERY: A MAJOR PRODUCT OF KNITTING

Before the sixteenth century, the Anglo-Saxon word *hosa* designated a woven cloth garment that covered the lower portion of the body as well as the legs. As knitting was popularized and practiced to a great extent throughout England and Scotland, it soon became customary to knit the leg coverings separately by hand. In the course of time these garments became known as stockings.

Wool was used for such hand knitting. When William Lee invented the knitting machine, the English queen encouraged him to adapt it to the knitting of silk stockings rather than wool ones, as she feared that such a machine would take away the livelihood of the wool hand-knitters. But credit for the later development of machine-knit silk stockings must be given to France, as Lee was invited to that country to set up his machines there when the queen of England failed to grant him a patent. Misfortune still followed William Lee, and he died in France before the full value of his knitting machine became apparent.

Hosiery is an important knitted product, and its cost is often a large item in the clothing budget of the consumer. The construction of hosiery should be of interest because it has a bearing on the serviceability of the article. In most cases, the better-constructed hosiery is well worth its extra cost, provided it is given proper care in wearing as well as in laundering.

**Yarns Used for Hosiery.** *Silk* has always been most popular for hosiery because it is strong and elastic and has a pleasing soft, luxurious texture.

As silk strands are not of even diameter throughout their length, the use of one continuous yarn (which is typical of the knitted construction) had a tendency to develop noticeable rings at points where the diameter of the strand changes, though ever so slightly. A more even texture has been obtained by knitting silk hosiery on a machine with a three-carrier attachment, so that three separate yarns may be used instead of one continuous yarn. In this way, each yarn appears on every third row, and any irregularities of size are scattered over a large area and are not readily discernible. Silk stockings knit by this method are called three-carrier construction or *ringless* hose.

*Cotton* is suitable for hosiery as it is soft and absorbent and dries quickly; it has less tendency to run when a thread is broken. *Wool* is adaptable to hosiery chiefly for warmth. The grade of any of these yarns will have an important bearing on the quality and price of the stocking.

*Rayon* hosiery does not possess the elasticity of silk and may not be expected to give comparable service, yet conditions brought about by World War II greatly advanced the adaptation of rayon for hosiery. High-tenacity rayon will doubtless have its share of the postwar market.

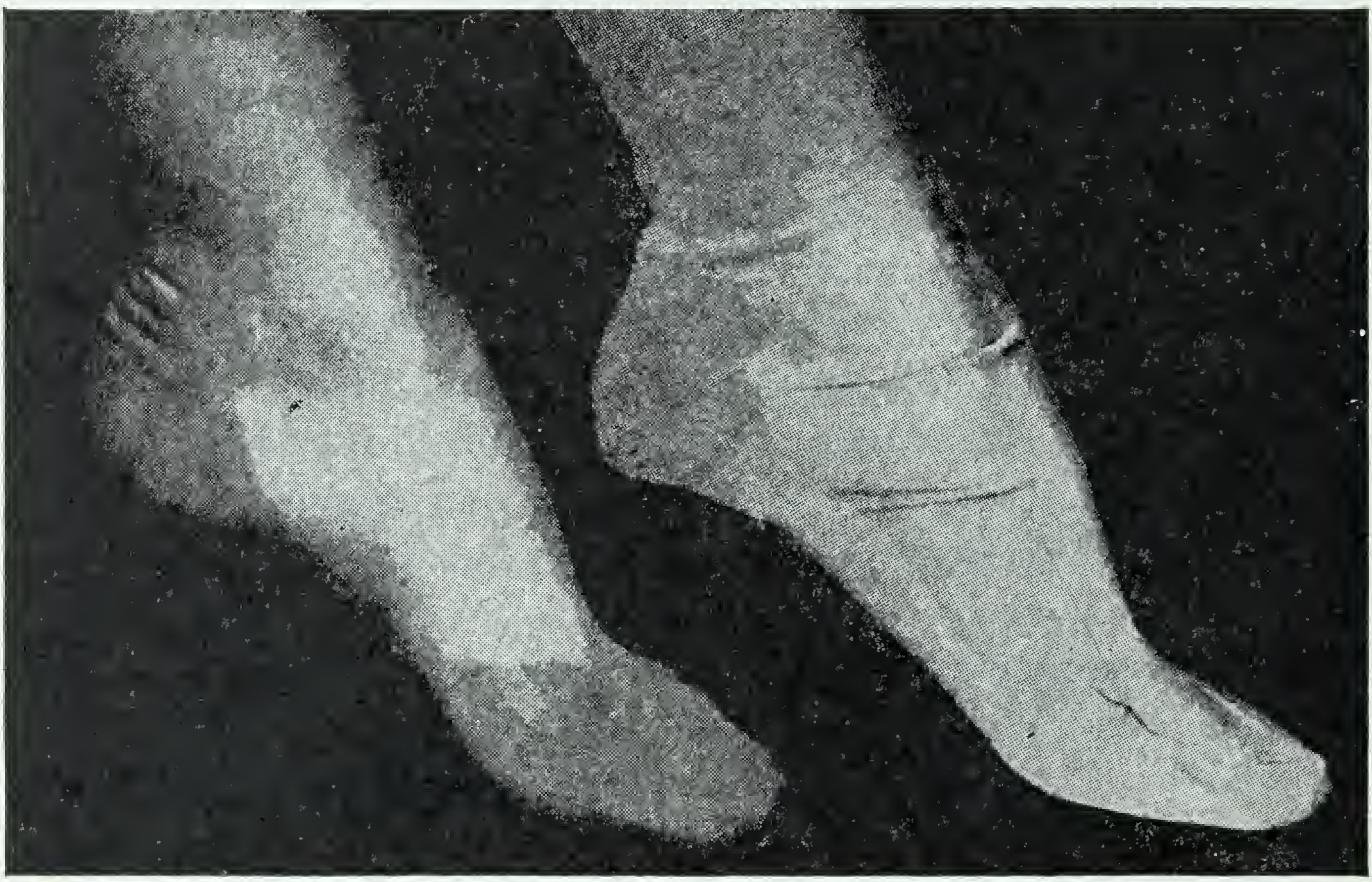
As *nylon* is a stronger and more elastic yarn than silk, nylon became the first yarn that was acceptable for fine hosiery in place of silk. Nylon has a greater resistance to abrasion and outlasts silk in the heels and toes of stockings. It lacks the absorbent quality of silk, however. Once a thread is broken, a nylon stocking runs as fast as silk, and it snags more easily.

Nylon yarn can be spun into fine deniers, so that, like silk, a large variety of styles, types, and weights of women's nylon hosiery can be made. At first, the full-fashioned construction was used, but the use of the circular-knit construction on high-count needle machines increased because nylon can be preset by heat. The preboarding operation stabilizes the nylon stocking fabric against distortion of stitch by subjecting it to conditions higher in temperature than those that will be subsequently encountered.

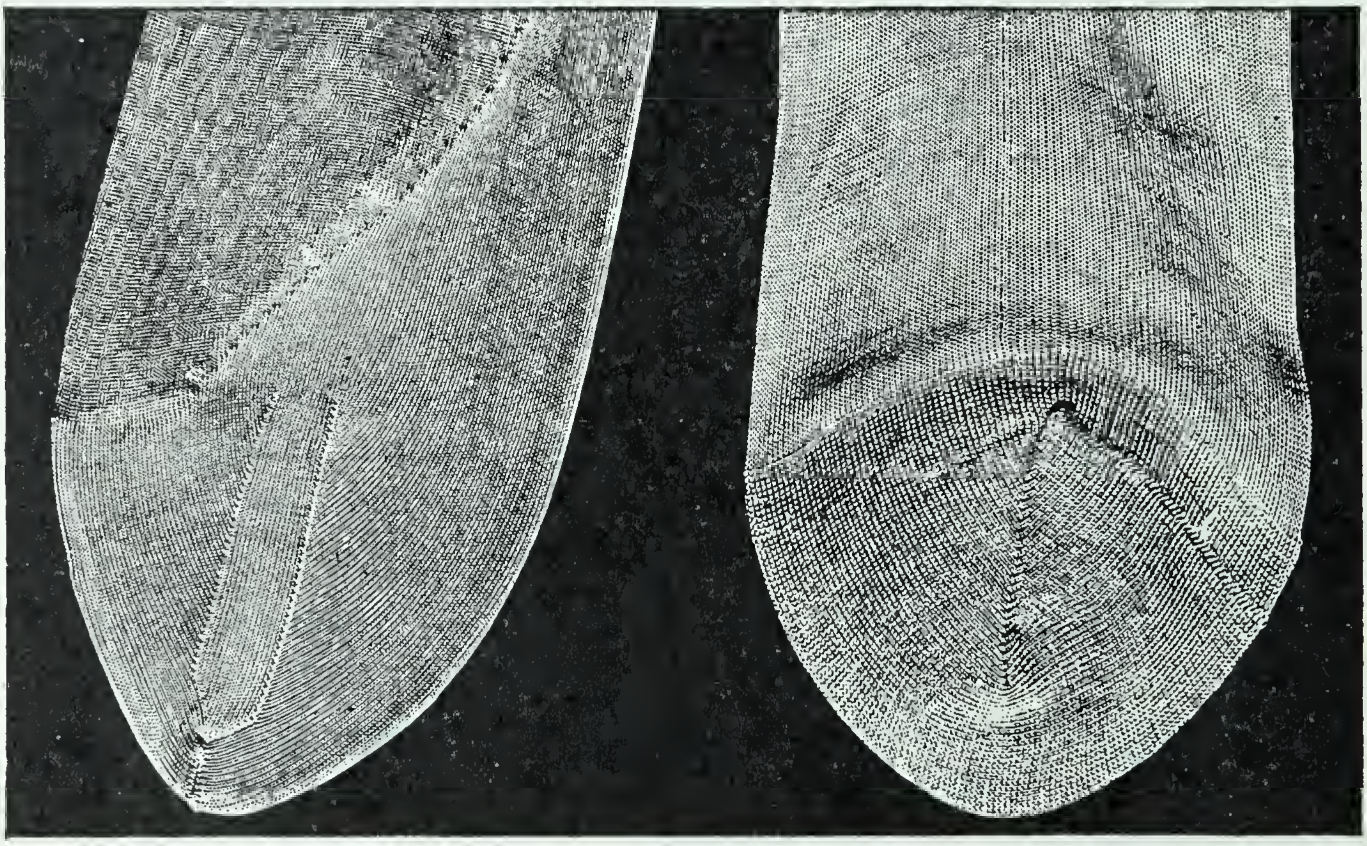
In the postwar period, nylon will be one of the principal hosiery yarns.

**Types of Hosiery Construction.** There are four types of hosiery construction: (1) full-fashioned; (2) circular, or seamless; (3) fashioned seamless; (4) cut and tailored.

*Full-fashioned Hosiery.* Full-fashioned hosiery receives its name from the narrowing process that is performed during the knitting



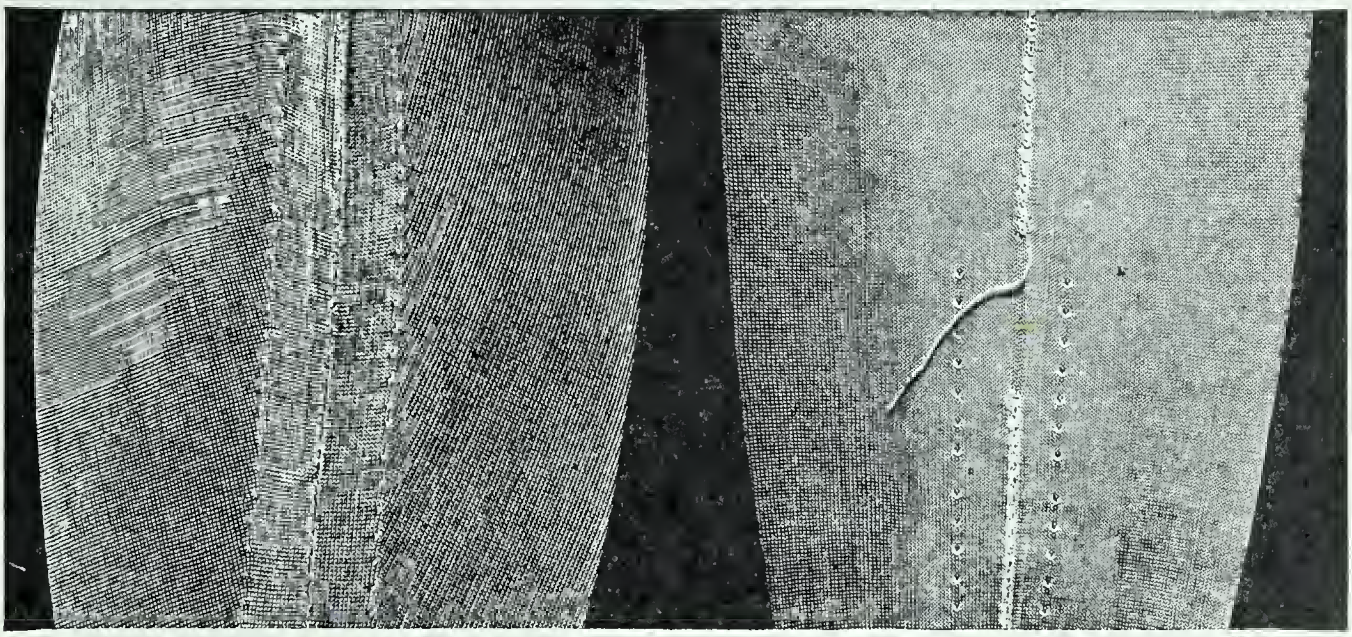
The foot of a full-fashioned stocking (at left) is shown for comparison with the foot of a circular-knit stocking (at right). Other illustrations in this chapter show how the full-fashioned construction is knit to the shape of the foot.



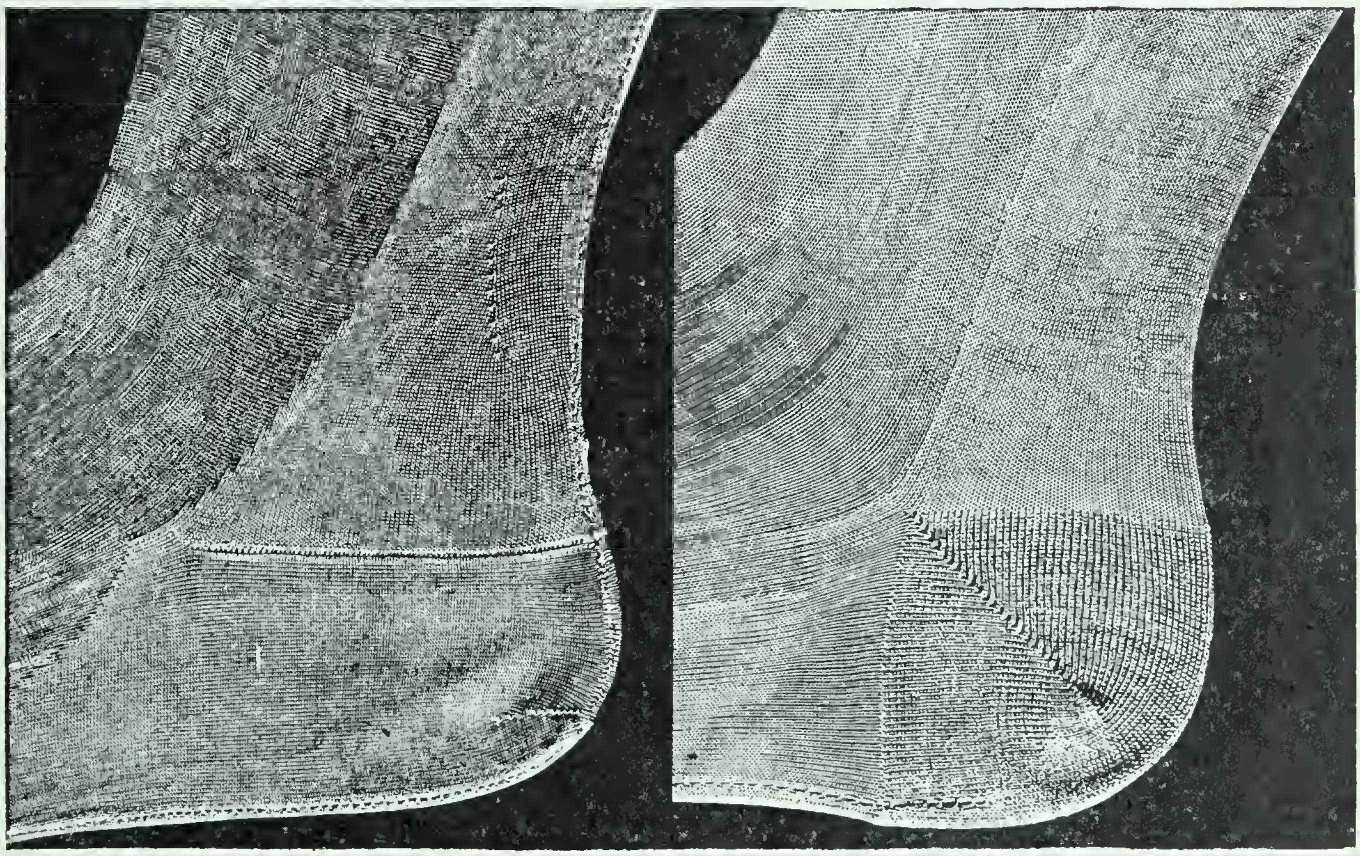
Detailed construction of the well-shaped toe of a full-fashioned stocking (at left)' is shown for comparison with the toe of a circular-knit stocking (at right).

operation in order to shape the hose to fit the leg. The fabric is knitted flat on two separate machines called the *legger* and the *footer.*

The legger knits the leg of the stocking as well as the heel. It drops loops at appropriate points between the knee and the ankle, thus



Detailed construction of the leg of a full-fashioned stocking, shaped in the knitting, is shown at the left. The mock seam and simulated fashion marks may be noted in the circular-knit stocking at the right.



The well-shaped construction of a full-fashioned heel can be seen at the left. At the right is the heel of a circular-knit stocking.

tapering the width of the stocking. Stitches are also dropped to shape the instep and the heel. The leg is then transferred to the footer, and the foot is knit to the leg. Recently, both operations have been combined on one machine, called a *single unit.*

When the selvages are joined together, the stocking is fully shaped. The joining produces a noticeable seam on the back of full-fashioned hosiery. Small dots, called *fashion marks,* appear on both sides of the seam indicating where the stitches were decreased during the narrowing process. Lines or wales radiate from these fashion marks.

Because full-fashioned hosiery is shaped in the knitting operation, its fit is assured and its shape is retained after wearing and washing. On all parts of full-fashioned stockings, there are the same number of loops to the inch.

*Circular-knit, or Seamless, Hosiery.* Circular hose is knit from hem to toe on a circular machine and is therefore seamless. There are the same number of stitches in the width of circular-knit hosiery from top to toe, making the hose of even width throughout its length. Therefore, certain areas must stretch in order to fit the leg and foot and will eventually show signs of strain. After wear and laundering, circular-knit hose returns to its original tubular shape.

Circular-knit hosiery can be made to simulate full-fashioned hosiery by using the more expensive yarns that ordinarily go into the manufacture of better-quality hose and by using mock seams with tuck stitches to resemble fashion marks. The tuck stitches can be recognized as such by noting whether or not the number of wales is the same above and below the fashion marks. Also, in circular-knit hose, the wales run parallel with the fashion marks; in full-fashioned hose, the wales radiate from the fashion marks.

The application of a seam on the back of circular-knit hosiery simulates the true seam of the full-fashioned construction. Circular-knit hose is also known as *mock-seam hosiery.*

*Fashioned Seamless Hosiery.* Fashioned seamless hosiery is knit on a special flat machine. The hose is started at the toe, where only a small number of needles is used. As the stocking is widened from ankle to calf and finally to hem, one needle at a time is added to obtain the full-fashioned effect. The added stitches form a V at the back of the leg. This V identifies fashioned seamless hose.

The fashioned seamless construction makes a comfortable stocking because the seam in the foot is eliminated. Seams are associated with the more popular full-fashioned construction, however, and fashioned seamless hosiery is generally given a seam down the back of the leg. Fashioned seamless hose is usually made from cotton, wool, and the coarser rayon yarns.

*Cut and Tailored Hosiery.* Cut and tailored hosiery is an inexpensive type of hose. In this construction, circular hose is cut up the back of the leg, and the hose is seamed to fit. This method makes it possible to cut stockings from plain or lace fabrics and to seam them after conforming the fabric to the shape of the leg.

**Women's Silk Hosiery.** In the production of silk thread for the hosiery industry, certain standards have been established. These standards indicate the nature of the yarn that is used—or thread, as it is customarily called. The quality of the thread, the number of strands, and the amount of twist to the inch are all factors to be considered when judging silk hosiery.

The number of strands in a silk thread indicate the size of the thread; that is, the *thread count.* From 1 to 12 strands may be used. Thus, when hosiery is termed 4-thread, it means that 4 strands have been combined to make the final thread. Each of these strands may have a certain amount of twist, and the final thread may have additional twist after the strands have been combined.

*Amount of Twist.* A high grade of fiber must be used in thread that is to be highly twisted, so that the thread may stand the strain of twisting. If silk is used, there will naturally be more silk content in highly twisted threads because more turns take up more silk. High twist gives strength, resiliency, and resistance to snagging, as well as the favored dull appearance. Stockings made with highly twisted threads fit better, as they cling to the ankle and knee, thus preventing bagginess.

The amount of twist is indicated by the following kinds of silk thread. Where more than two strands are used to form the final thread, at least half of the total twist required for each type of thread must be inserted in the initial twisting of the single strands.

*Tram*—single strands having 3 to 6 twists to the inch.

*Grenadine*—over 20 twists to the inch in each strand; more than 30 twists to the inch in the final thread.

*High twist*—no twist in the single strands, but at least 25 twists in the final thread.

*Crepe twist*—for each strand, and for the final thread, the minimum total twist is based on the size of the thread: 2-thread, 100 twists to the inch; 3-thread, 80 twists to the inch; 4-thread, 60 twists to the inch; 5-thread or more, 50 twists to the inch.

*Weight.* The number of strands that are combined in the thread determine the thread count and the weight of a silk stocking. For very hard wear, the consumer should choose *service weight,* which has from 7 to 12 strands in the final thread. A smaller number of strands, such as 5 or 6, produces *semiservice* or *service-sheer weight.*

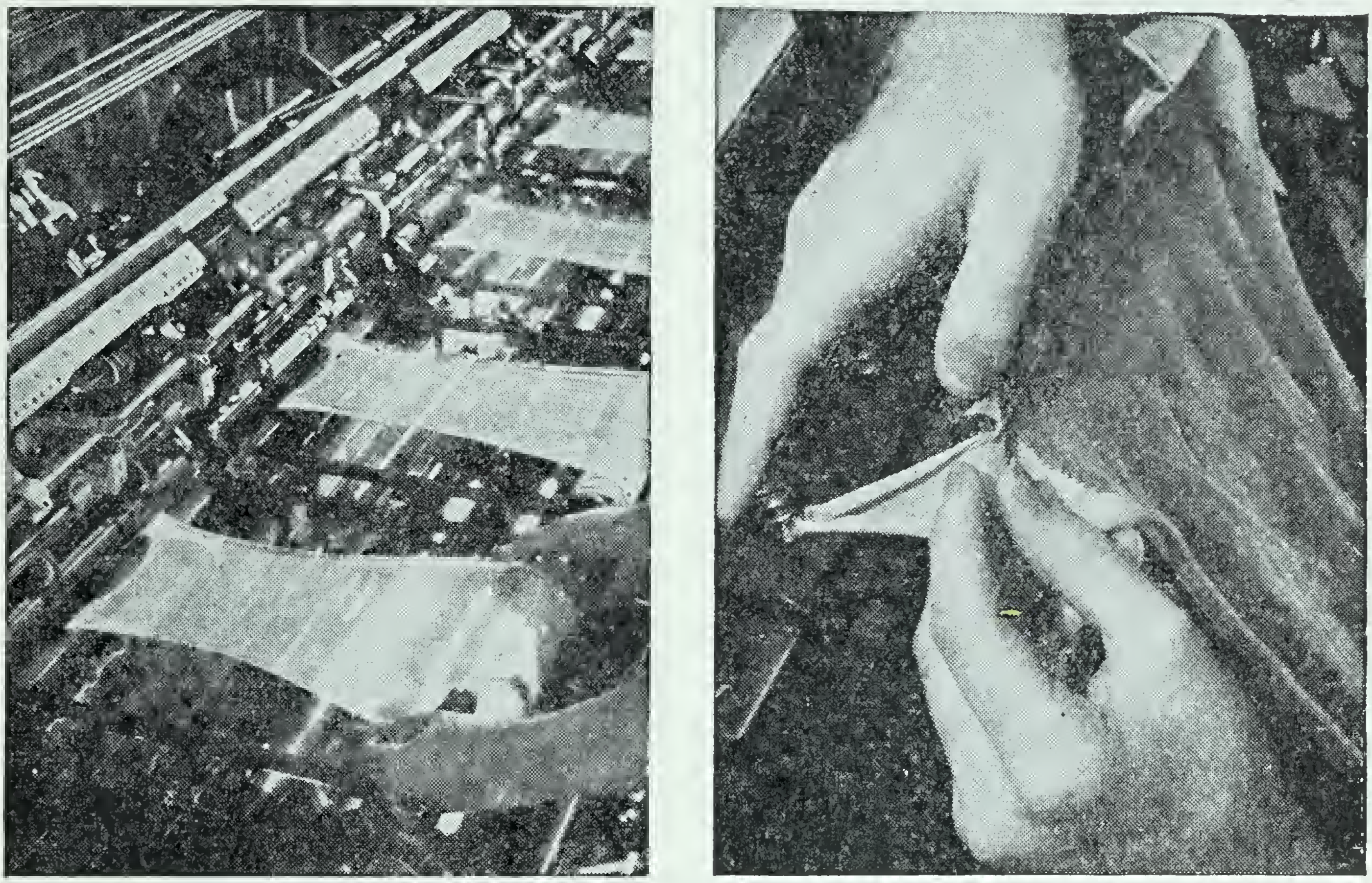
Where delicacy and sheerness are desired, 2 to 4 strands to the thread are used. This weight is known as *chiffon weight.* It has a more attractive appearance than heavier weights. Chiffon stockings require a finer grade of silk for successful knitting; and the strands, though few, must be of high quality without flaws, knots, or other imperfections.

A 4-thread silk stocking is the sheerest weight that will give reasonable wear; 3-thread or 4-thread is usually selected for informal dress wear. For formal occasions, durability is sometimes sacrificed for sheerness.

The weight of silk hosiery, however, is not the only factor that indicates quality. The fineness of construction must be considered; this is determined by the gauge.

*Gauge.* Regular-sized silk hosiery is knit on a 14-inch needle bar; extra-sized silk hosiery, better known in the trade as *out-size,* is knit on a 15-inch or a 16-inch bar. The full width of the bar must be used in order to produce stocking fabric of standard width, which gives full satisfaction after washing. Sometimes, to reduce manufacturing costs, needles are left idle at the end of the bar. Such skimping decreases the stretchability of the stocking.

On the needle bar, a specified number of needles is used for each 1½ inches of stocking width. This number indicates the fineness of construction and is called the *gauge.* The greater the number of needles used for each 1½ inches, the finer the needles must be, and



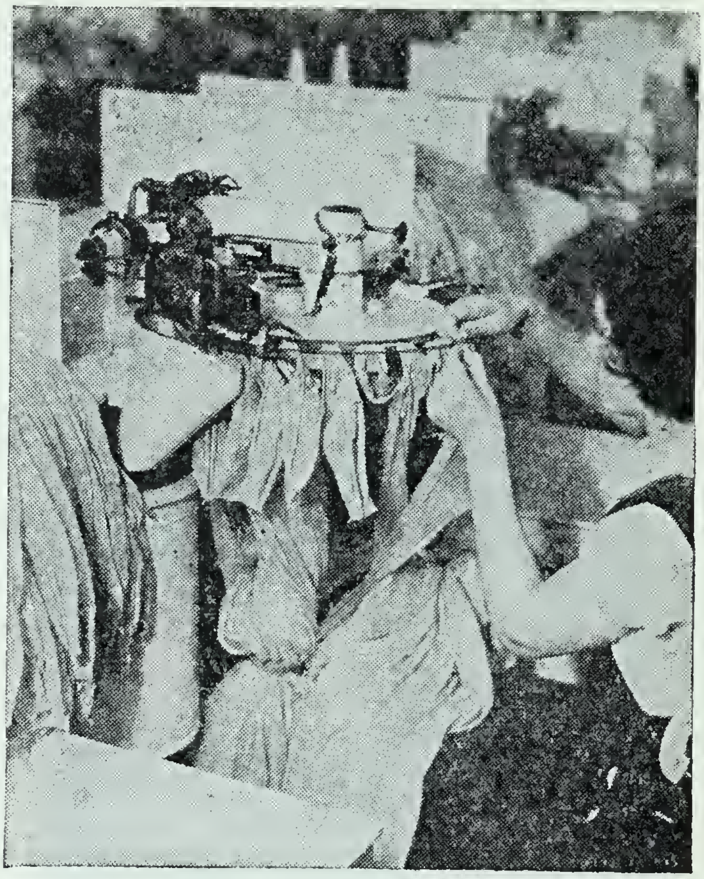
*Left:* On the legger, the leg of the stocking is knit complete with welt and afterwelt. The calf is shaped, the ankle narrowed, and the reinforced French heel knit in. *Right:* The stocking is then transferred to the topping table, where the last row of loops is fitted over a bar of needles. Great care must be taken to avoid splitting a thread.

the finer will be the stitches; consequently, the higher the gauge number, the finer the construction. For example, a 48-gauge stocking is knit with 48 needles to each 1½ inches; a 51-gauge is knit with 51 needles to each 1½ inches. The higher-gauge stocking will have more stitches to the inch, giving greater elasticity and durability.

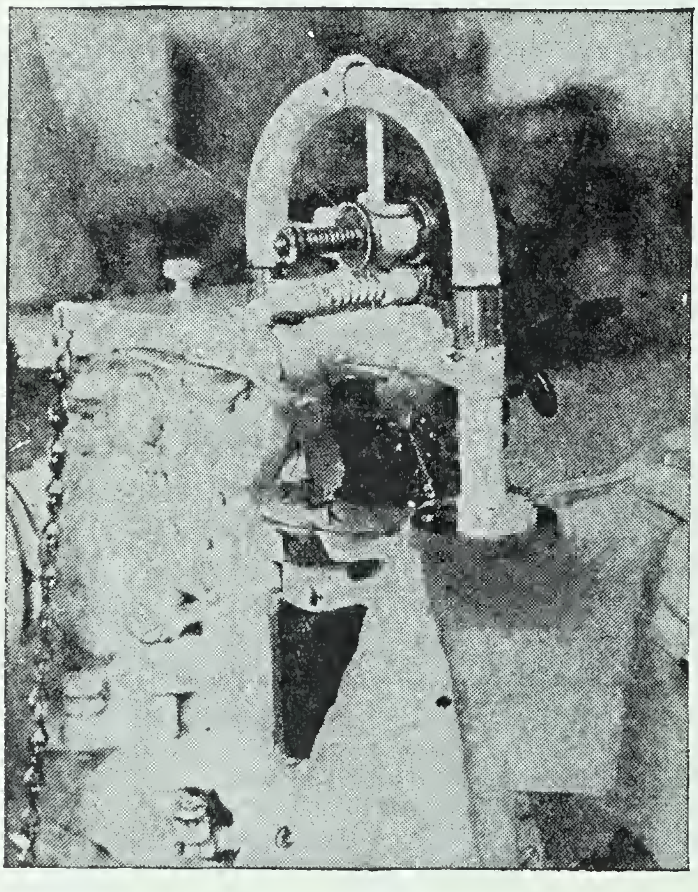
*Thread and Gauge Standards.* The consumer must consider both thread and gauge when purchasing hosiery, as each factor contributes degrees of elasticity and strength that, combined, indicate the probable durability of the hose. Therefore, a 3-thread stocking that is being selected for dress wear should be of at least 51-gauge, because the greater number of stitches to the inch offsets the less strength that a 3-thread stocking has as compared with a 4-thread stocking.

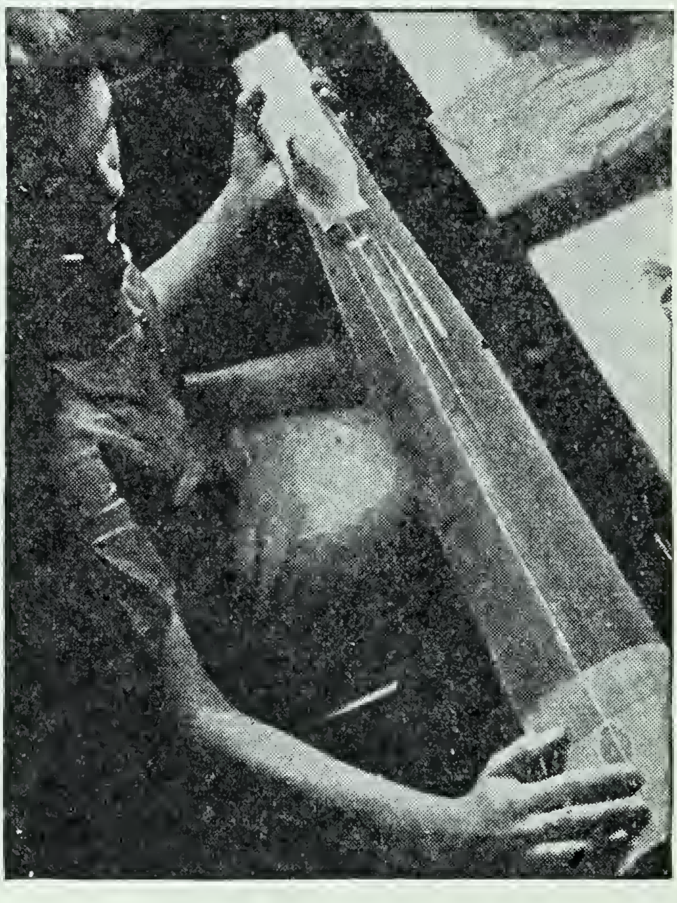
The 40-denier nylon stocking is approximately the equivalent of the 3-thread silk stocking.

**Men's, Children's, and Infants' Hosiery.** Men's, children's, and infants' hosiery, with minor exceptions, is circular-knit and is made of

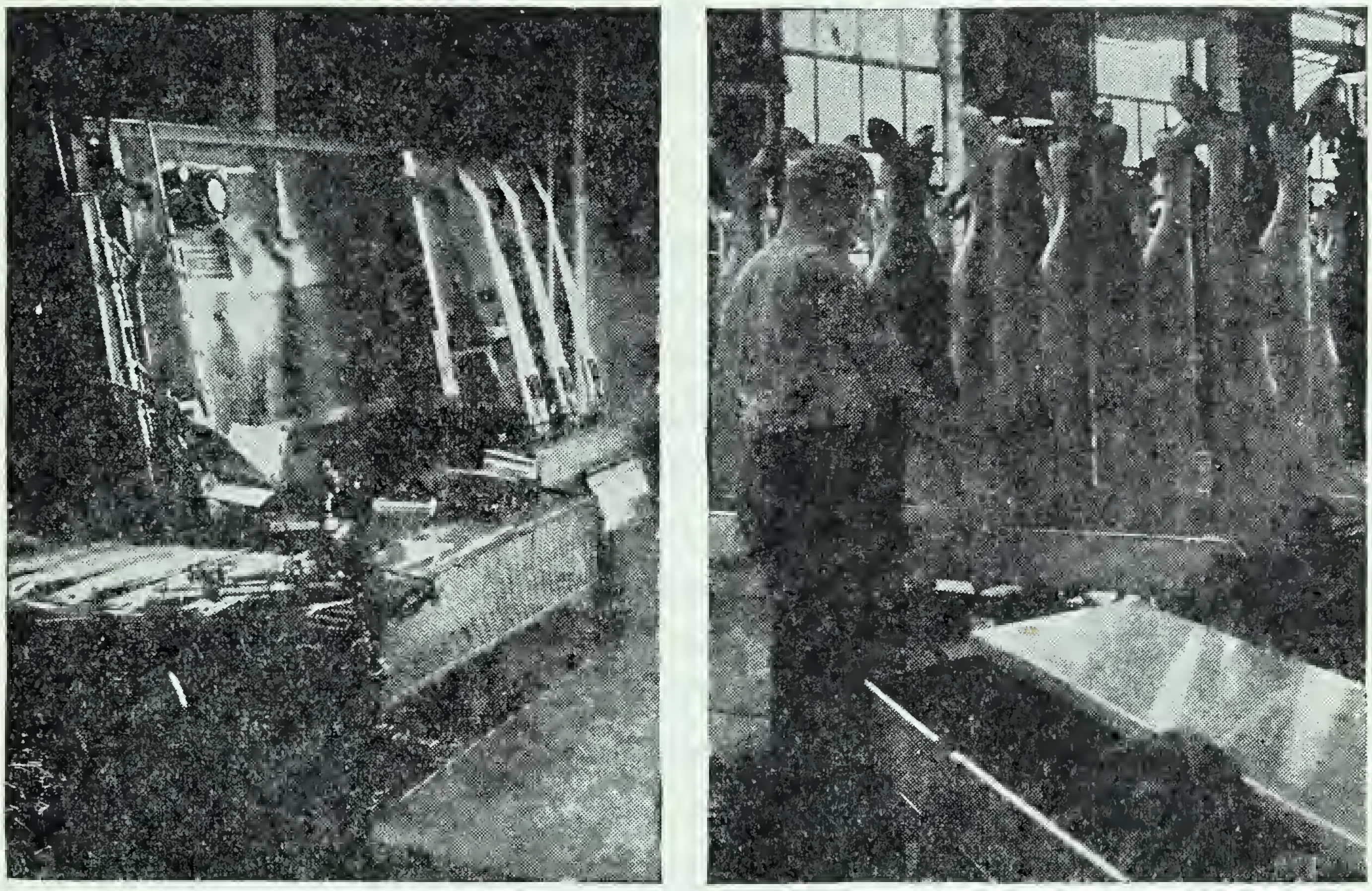


*Left:* The transfer bar with the leg attached is placed in the footing machine, and the footer knits the instep, sole, and toe. The points of wear are reinforced. *Right:* In looping, the toe and heel are finished.





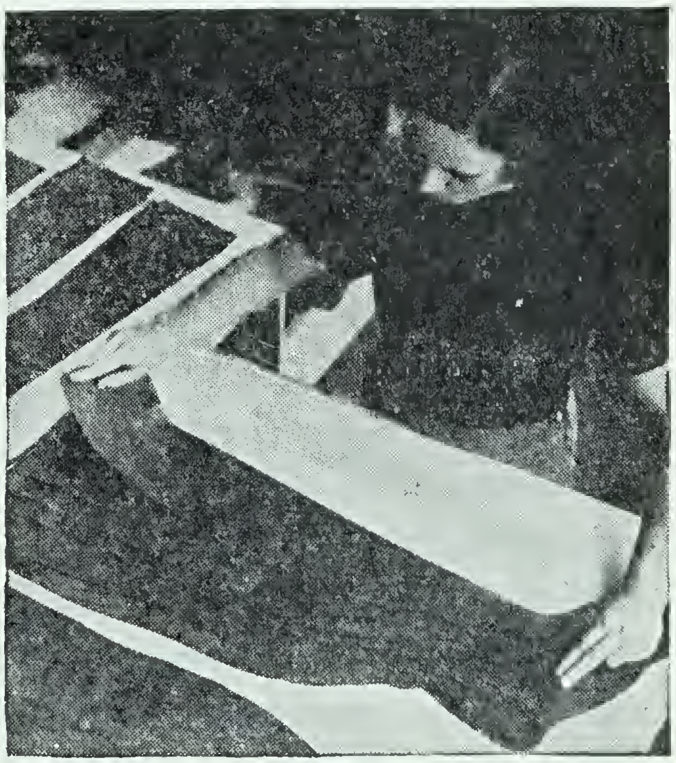
*Left:* The stocking is knit together from the point of the toe to the top, thus forming the knitted seam indicative of full-fashioned hose. *Right:* Each stocking is carefully examined for defects.



*Left:* In boarding, stockings are drawn on boards while still wet from dyeing. The stocking seam is carefully adjusted to the edge of the form. The forms are placed in a heat chamber having a temperature of 200 degrees Fahrenheit and are left there for a certain period. Shaping under heat sets the threads. *Right:* Aluminum forms are sometimes used to shape stockings after dyeing. This is simply another form of boarding.

any of the various kinds and combinations of yarns, in many styles and color effects. Elastic tops for this type of hosiery became popular before World War II, and will doubtless be in wide demand when rubber elastic is available in unlimited quantities.

**Dyeing of Hosiery.** Most stockings are dip-dyed or piece-dyed. This method is satisfactory if proper care is taken to insure evenness of color, for the flesh background quickly reveals inadequately dyed hosiery. By stretching



The stockings are ready for pairing according to size, length, color, and shade.

the seamed part of the stocking, the consumer can tell whether the dyeing was well done; unevenness of color indicates poor or incomplete penetration of the dye.

Hosiery is sometimes yarn-dyed. Ingrain stockings are made from yarns that were dyed before knitting. The amount of ingrain hosiery produced today is very small. A richer color results, but the hosiery is not so durable as when piece-dyed.

**Standards for Good Hosiery Construction.** Many factors contribute to the serviceability and durability of hosiery. These factors are summarized as follows:

1. *Grade of yarn.* The thread must be uniformly smooth and strong. No method of knitting can overcome the flaws of poor yarn.

2. *Thread Count and Twist.* The use of several strands gives added strength to the final thread. For dress and formal occasions, delicacy and sheerness are equally desired, and fewer strands may be used, preferably combined with high gauge. For strength, elasticity, and favored dullness, the twist must be just right. Overtwisting reduces the strength and elasticity of the yarn. The important thing to determine is whether the hosiery is to be worn for appearance only, or whether it is intended for light, moderate, or hard wear.

3. *Gauge.* The higher the gauge, the more and finer the stitches; but the gauge must be properly related to the thread count and the purpose of the stocking.

4. *Fineness and Evenness of Knitting.* The ringless knit in both foot and leg is necessary in good-quality hose.

5. *Color.* Dyeing should produce colors that are clear, true, and rich in tone. They should be fast to washing, light, and perspiration.

6. *Elasticity and Length.* Sufficient elasticity in the length and the width of a stocking is essential in order to provide full comfort when the leg is flexed. A good lengthwise stretch proves that hosiery has not been pulled to length but knitted to size. A full length of at least 30 inches is standard for the average woman; 27 inches for short women; and 33 inches for tall women. Hosiery that is too short is tight over the knee when the supporters are fastened and tends to develop breaks and runs. When hosiery is too long, it must be fastened below the welt, and this causes runs. Men's hosiery should be 14 or 15 inches long.

To test the elasticity of a woman's stocking, stretch it crosswise, first at the welt, which should stretch to about 12 inches; then at the instep, which should stretch to about 8 inches. When released, both welt and instep should spring back to shape quickly.

7. *Strength of Reinforcements.* The reinforcement, or splicing, at the heel and toe must be symmetrical. Strengthening of the underside of silk with cotton is called *plaiting.* It should be done with the best grade of cotton, which will match the silk when the stocking is dyed.

Relation Between Size of Shoe and Size of Stocking [1]

| *Size of Shoe* | *Men's Hosiery* | *Women's, Misses', Youths' Hosiery* | *Children's and Infants' Hosiery* |
|---|---|---|---|
| 1 | .. | 8 | 4 |
| 1½ | .. | 8 | 4 |
| 2 | .. | 8 | 4 |
| 2½ | .. | 8½ | 4 |
| 3 | .. | 8½ | 4½ |
| 3½ | .. | 8½ | 4½ |
| 4 | .. | 9 | 4½ |
| 4½ | .. | 9 | 4½ |
| 5 | 9 | 9 | 5 |
| 5½ | 9½ | 9½ | 5 |
| 6 | 9½ | 9½ | 5½ |
| 6½ | 10 | 10 | 5½ |
| 7 | 10 | 10 | 6 |
| 7½ | 10½ | 10½ | 6 |
| 8 | 10½ | 10½ | 6½ |
| 8½ | 11 | 11 | 6½ |
| 9 | 11 | 11 | 7 |
| 9½ | 11 | .. | 7 |
| 10 | 11½ | .. | 7 |
| 10½ | 11½ | .. | 7½ |
| 11 | 12 | .. | 7½ |
| 11½ | 12 | .. | 7½ |
| 12 | .. | .. | 7½ |
| 12½ | .. | .. | 8 |
| 13 | .. | .. | 8 |

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[1] Courtesy National Association of Hosiery Manufacturers.

8. *Joining at Instep.* The joining of the leg and foot at the instep should be reinforced to allow a 7-inch stretch without binding or wrinkling. Here, the stocking must be firm because the weakest part of a stocking is the point where the joining line touches the heel at the instep.

9. *Seam.* From welt to toe, the seam of a stocking should be narrow, flat, straight, and strong. Stitches should be close and show no gaps, loops, or unclipped threads at the end.

10. *Finish.* Good stockings are soft and pleasing to the touch, showing that no metallic substances have been used. Color, feel, and clarity when held to the light are essential qualities for style and appearance.

**Care of Hosiery.** Hosiery should be washed after each wearing, as perspiration weakens the fiber. Unusual care is necessary in washing, as rough skin or sharp fingernails cause snags, which eventually result in runs. Obviously, rings should be removed from the hands when hosiery is being handled.

Lukewarm water with suds made from mild soap or soap flakes should be used, and the suds squeezed through the hose. Stockings should never be wrung or twisted. When drying, they should not be exposed to the direct heat of the sun nor hung near a hot radiator or stove.

These precautions apply to all types of hosiery. For wool stockings, the additional precautions for washing any wool fabric should be observed. See Chapter XVIII.

In addition to careful washing, the following suggestions will also help lengthen the wear of hosiery:

1. Strain on stockings, which tends to break the thread and produce runs, can be avoided by the proper distribution of garter support. Also, garters should be fastened to the folded top of the stocking while the knee is bent.

2. At least two pairs of stockings of the same color should be purchased at one time. This makes it possible to match pairs when a single stocking has been damaged.

3. Examine shoe linings frequently in order to detect development of roughness that may cause undue wear on stockings.

4. Keep stockings in a separate box when not in use, to prevent contact with anything that may mar their texture.

5. Select the proper size of hose according to well-fitted shoes. The size of the stocking should be at least a half inch longer than the wearer's foot. The accompanying chart is an aid to such selection.

*Test yourself on this chapter by answering these questions:*

1. What yarns are adaptable for hosiery? Which is preferred for general wear? For warmth? For sportswear?
2. What are the types of hosiery construction? Which is preferable, and why?
3. What is meant by ringless hose? What causes the rings? How may they be eliminated?
4. Give three suggestions for the care of hosiery other than care in washing.
5. Where is the weakest part of a stocking?
6. How would you judge a pair of stockings that you were considering purchasing?
7. How is the gauge determined when a stocking is being constructed?
8. How will the gauge affect the consumer?
9. How will the fit of shoes affect the wear of hosiery?
10. Why is it important to examine the reinforcements of hosiery?
11. By what methods are stockings dyed?
12. What are the average lengths of hosiery for women? For men?
13. What is the importance of the number of threads in hosiery?
14. How many threads do you recommend for formal, daytime, work, and hard-work occasions?

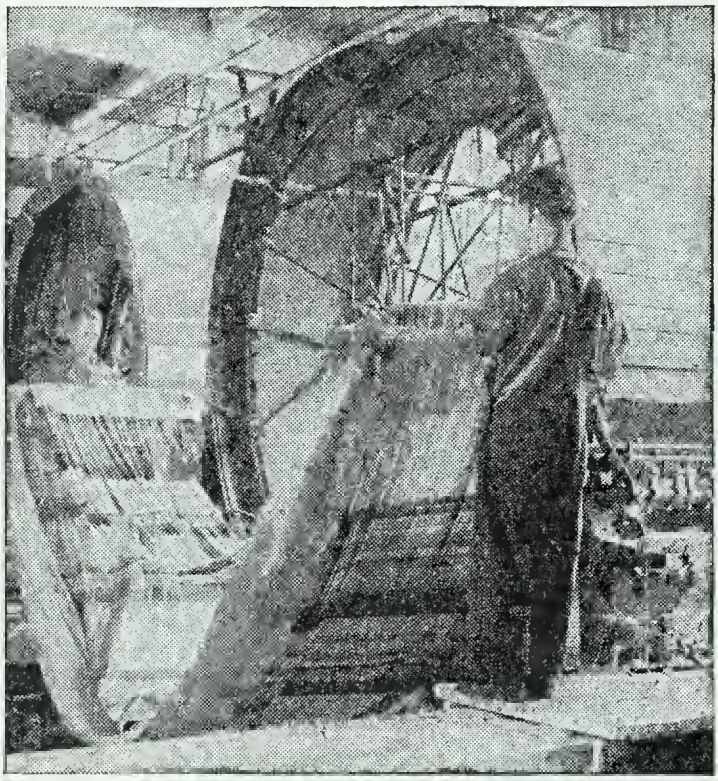
## Suggested Readings

Caplin, J., *Knit Fabrics.*
Schenke, E. M., *The Manufacture of Hosiery and Its Problems.*
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapter 5.
U. S. Department of Agriculture, Publication 342, *Hosiery.*

## CHAPTER XVII

# TEXTILE FLOOR COVERINGS

Floor coverings have been made from textile fibers for more than 5,000 years. Throughout civilization the production of rugs and carpets has formed a part of the history and culture of races and nations. Early kings and conquerors included valuable rugs among their treasures and trophies, and many of these famous pieces have retained values that in some cases are inestimable. Priceless handmade carpets and rugs woven hundreds of years ago in the Far East are exhibited today in museums as representative of the patient labor and creative art of weavers whose skills have been passed on through many generations.



Yarn for velvet rugs may be drum-printed. After removal from the drum, the yarn is suspended for a time to allow the dye to penetrate the yarn.

Well-chosen rugs or carpets serve as a colorful foundation for the decorative plan and color scheme of all rooms in the modern home. As floor coverings are among the most expensive items in the consumer's house-furnishings budget, careful consideration must be given to fiber, color, decorative character and design, size, and construction in order to obtain the best value for any price level.

**Rug Construction.** The terms *rug* and *carpet* are used synonymously, but the form or the size in which these coverings are manufactured differs. Rugs may vary in shape as well as in width and length; in general, certain size standards are maintained that have been adapted, in the larger rugs, to standard sizes of rooms.

Floor coverings are made from various kinds of fibers—cotton, silk, wool, rayon, mohair, jute, hemp, or grass straw. The wool fiber is most popular because wool offers the advantages of extreme softness, resiliency, absorbency to shock and noise, and, particularly, resistance to long wear when the right fibers and construction are used.

Construction factors explain differences in quality and price: for example, the quality and quantity of wool used, the length of staple, the amount of twist, and the number of ply in the yarns. Each factor has a definite bearing on the final price of the finished product.

The term *broadloom* does not refer to quality but describes a type of carpet that is woven on a loom wide enough to produce the width desired. The carpet is woven all in one piece—not formed by stitching narrow widths together.

**Terms Used in Carpet Industry.** Judging a rug for quality of construction requires some understanding of certain terms used in the carpet industry.

*Tufts* are the cut loops of surface yarns held in the small squares that are discernible on the reverse side of the rug. *Pitch* expresses the number of warp threads crosswise of the loom to each 27 inches of width. *Wires* refer to the number of tufts to the inch in the warp or lengthwise direction.

The construction of the rug is indicated by the closeness of the tufts in each direction—that is, by the pitch and wires. The number can usually be determined by counting the rows of fiber on the back of the rug.

Compact construction of the tufts, represented by a high number of pitch and wires, indicates a dense pile, showing that a greater quantity of wool has been used, with a resulting more durable product. Density of weave is considered the most important factor for determining the durability of floor coverings.

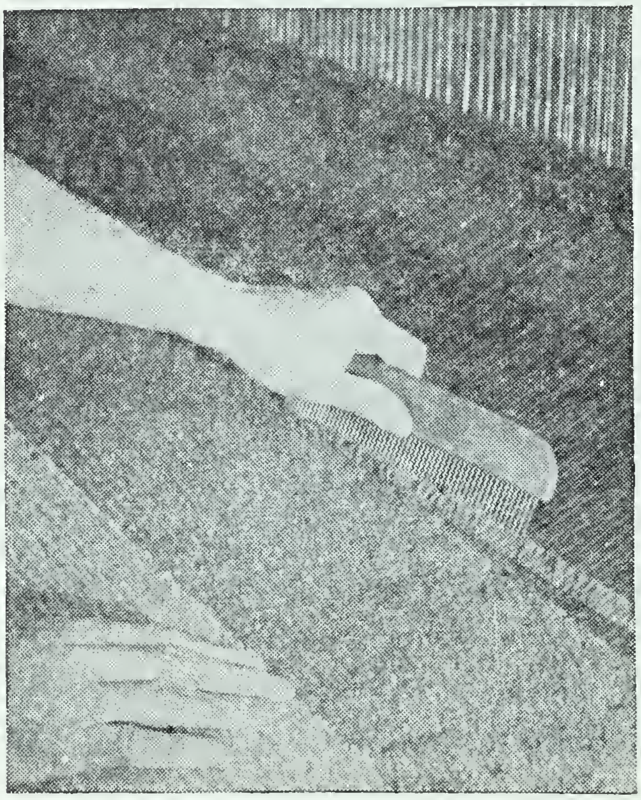
Additional crosswise yarns are used to bind the pile to the backing of the rug. The number of yarns used for this purpose is indicated by the term *shot.* In a two-shot construction, for example, one crosswise yarn can be seen between each row of tufts; the other crosswise yarn is behind the row. In the three-shot construction, there are two crosswise yarns between each row of tufts, and a third yarn is in back. As the three-shot construction requires additional yarn and more loom operations, it is more expensive; but it increases durability.

**Classification by Weave.** Rugs and carpets may be classified according to weave, of which there are three general types:

1. Cut pile. Examples are Oriental, chenille, Wilton, Axminster, and velvet.
2. Uncut pile. Examples are tapestry and Brussels.
3. Flat weaves. Represented in novelty and special-purpose rugs made from miscellaneous fibers. Such rugs can ordinarily be used on either side.

## Domestic Rugs

In the United States, floor coverings are often classified as domestic and imported. The *domestic* group includes all kinds of rugs made in this country regardless of the source of their raw materials. The *imported* group includes Oriental, Chinese, Indian, and other foreign products. Today, these divisions and even specific types of rugs do not tell the consumer all that should be known because both good and poor qualities are found in all weaves.

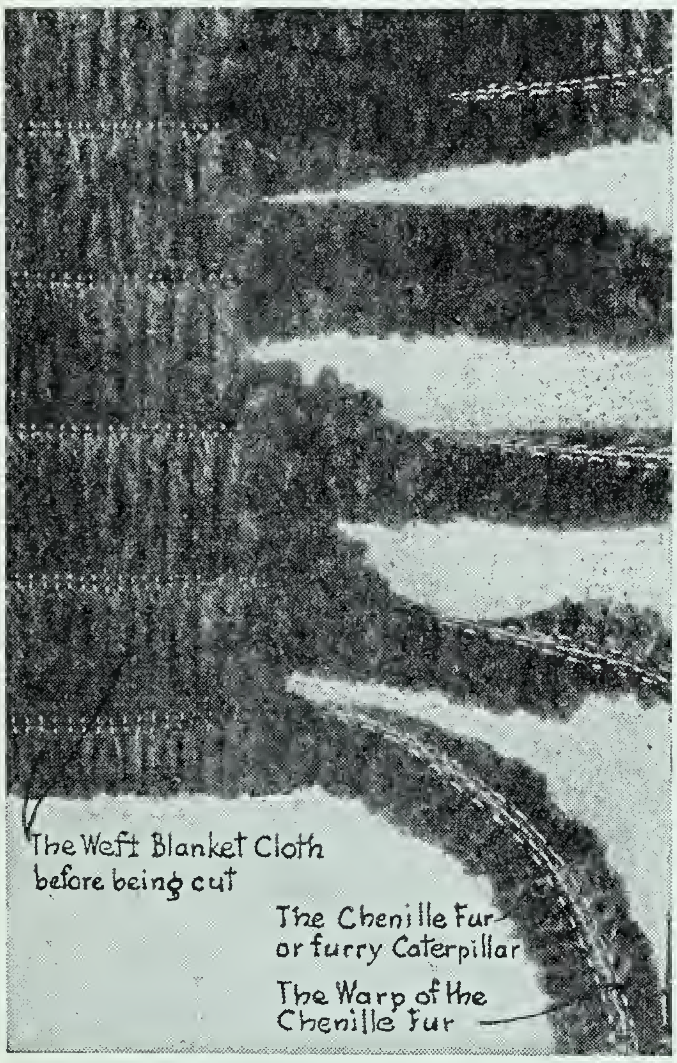


Hand tufting in chenille weaving. A steel comb is used to bring the surface yarn in the fur up through strong cotton catcher warp threads as four motions of a shuttle weave the heavy backing yarn to the base of the fabric.

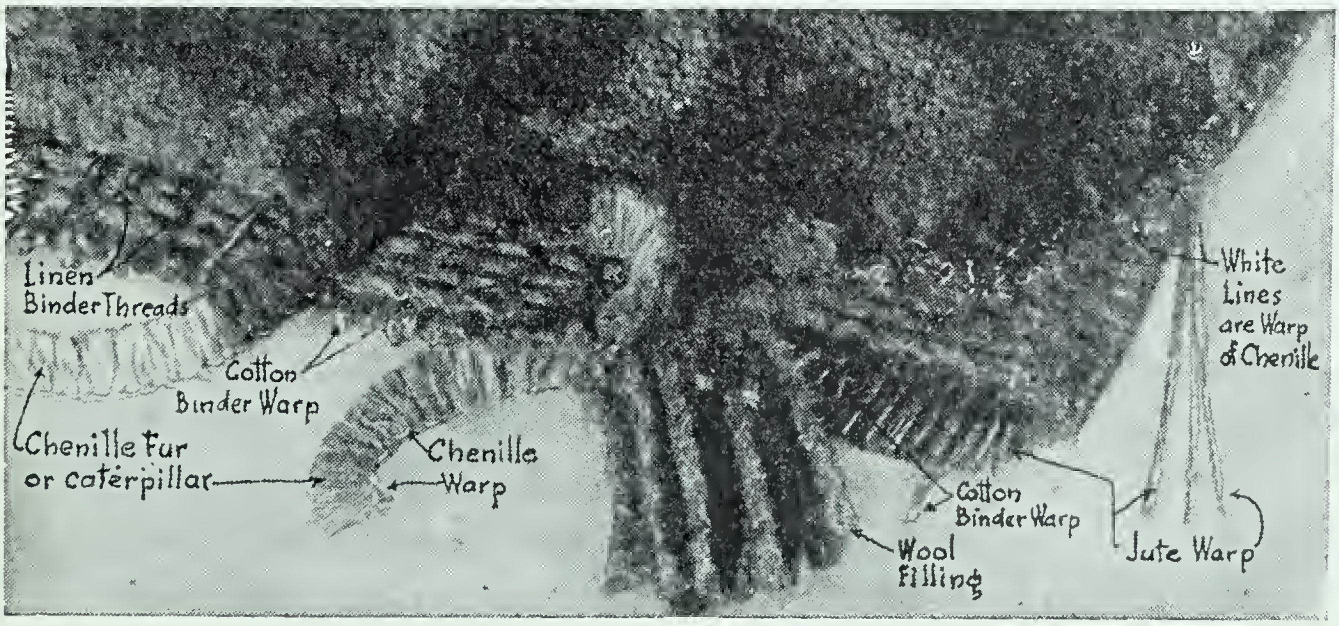
**Chenille.** Chenille is the most expensive of the domestic types; and it offers the widest range of possibilities with respect to depth of pile, design, colorings, and width. Chenille may be woven even as wide as 30 feet without a seam, and can be made as a single unit to fit irregularly shaped areas. It can be produced with a pile up to 1 full inch in height. This height, when supported by a heavy wool cushion back, gives a luxuriously soft and resilient quality and remarkable durability.

The chenille construction requires two separate loom operations. First, woolen or worsted yarns are woven into a blanket containing cotton warp threads. Actually, this blanket is composed of vertical woolen or worsted yarns bound together by the cotton warp.

Another machine cuts the woolen filling halfway, producing furry strips, which are held together by the cotton yarns in the center. This strip, which resembles a caterpillar, is pressed into V-shaped form, and the separate ends are tied together, forming a continuous chain. This chain is subsequently used on the second loom as a filling for the final weaving of the chenille rug.

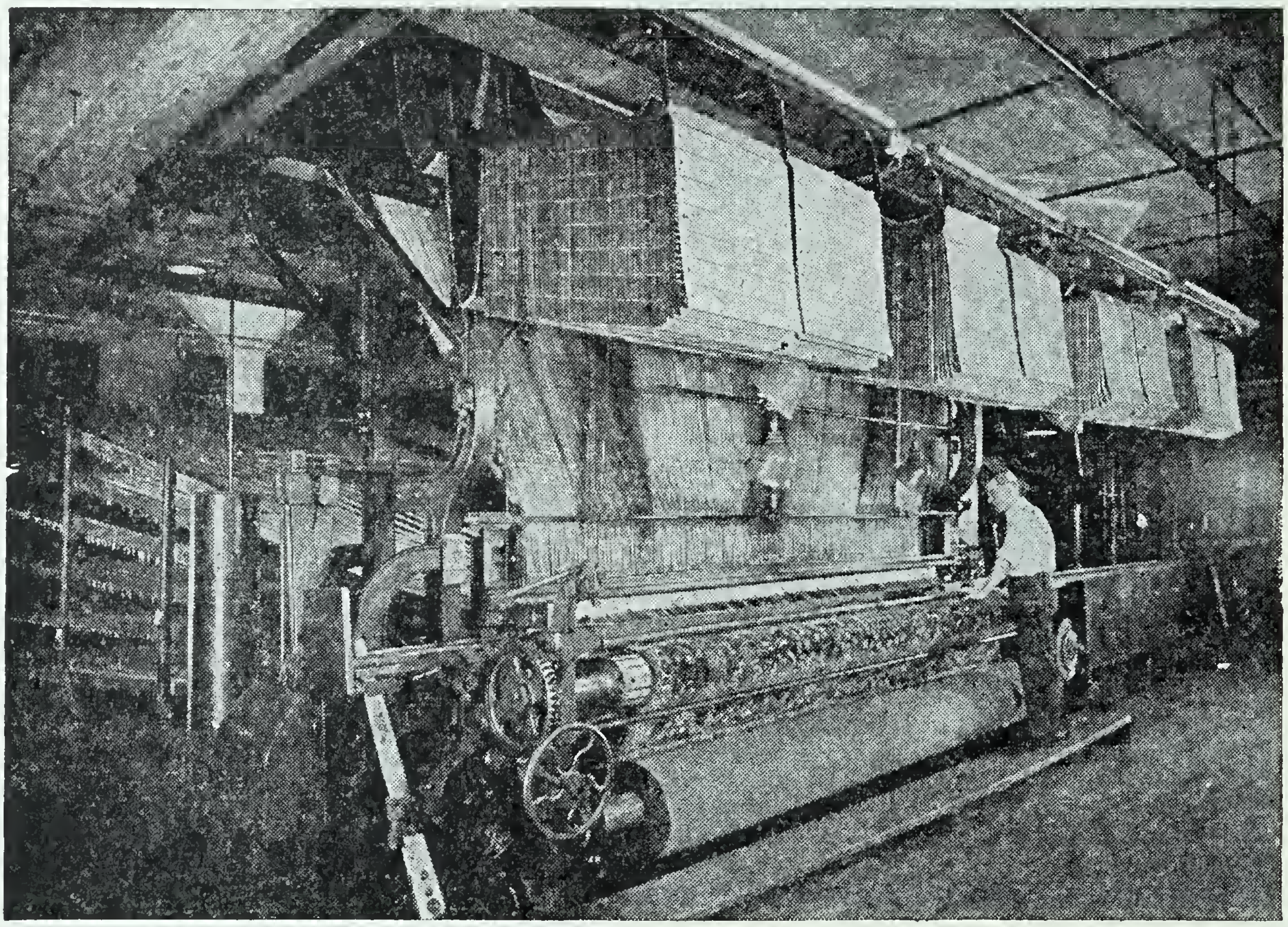

The Weft Blanket Cloth before being cut
The Chenille Fur or furry Caterpillar
The Warp of the Chenille Fur

*Left:* Woolen blanket cloth from which chenille fur, or hairy caterpillar, is made. The cloth is shown partly cut so that the warp of the caterpillar may be seen. *Below:* Chenille construction shown in detail.



A well-constructed chenille uses a fine quality of wool and a densely packed high pile, which results in the durability characteristic of this weave.

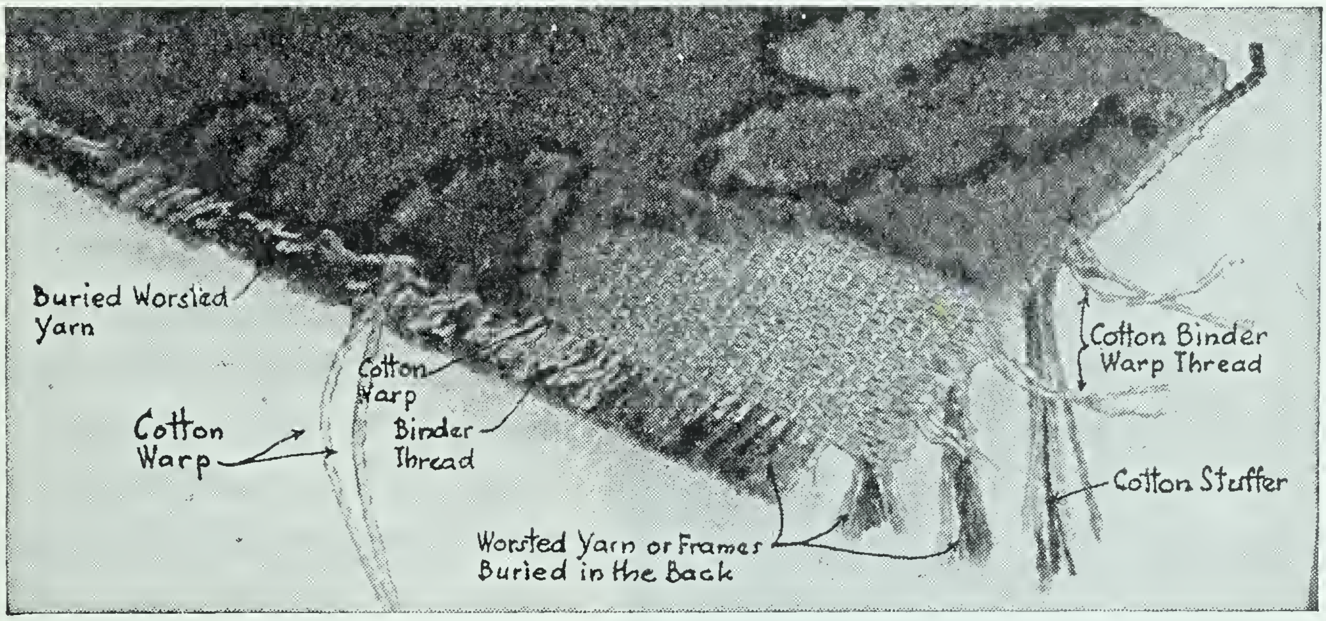
*Smyrna* rugs resemble chenille, as they are made with a chenille fur; but the fur is twisted into a round yarn instead of the V shape of the chenille type. Also, a shot of fiber filling makes the Smyrna rug reversible—the pattern and pile are alike on both sides. It has a shorter pile than the chenille.



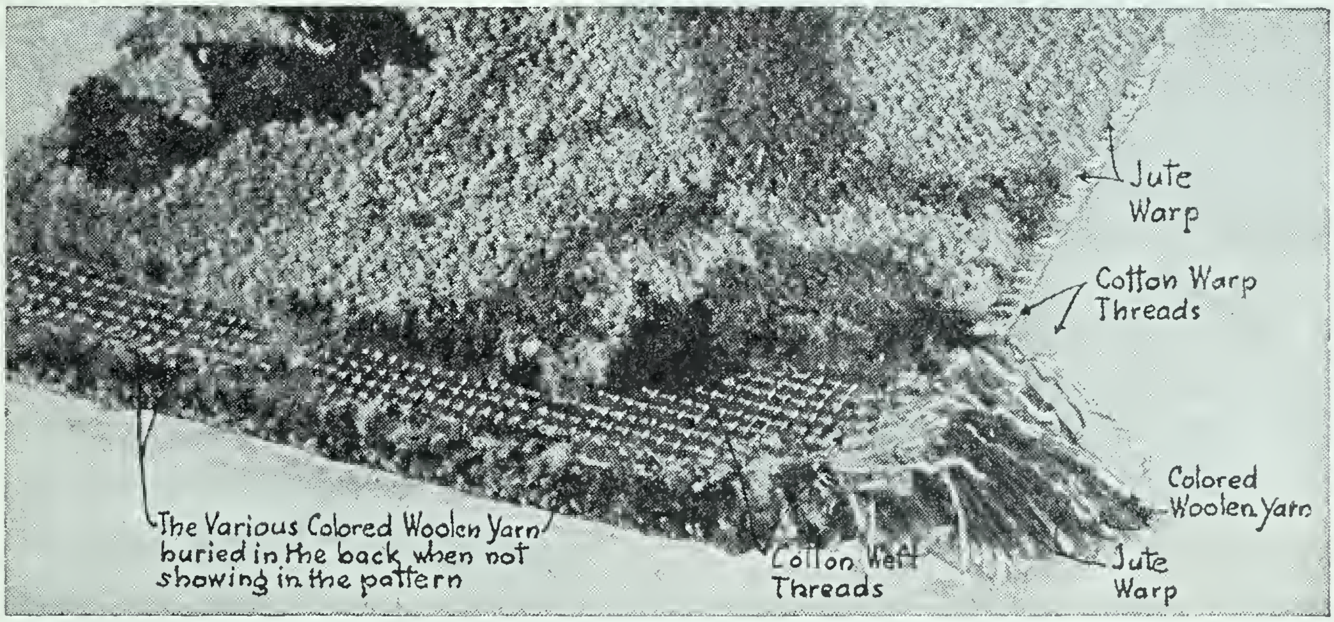
In Wilton weaving, thousands of surface yarn ends are threaded through eyes in lift wires connected with the Jacquard mechanism. In each split of the reed, one yarn end is raised by the Jacquard control to form the surface design.

**Wilton.** Wilton is an expensive weave to manufacture, ranking next to chenille. It is always woven on a Jacquard loom and is considered one of the best of all machine-made rugs.

In weaving the Wilton, the surface yarn is held in trays called frames. Each frame holds spools wound with yarn of the same color. If there are six full colors in the pattern of a Wilton, there must be six frames. In a six-frame Wilton, only one of the six pile yarns appears on the surface at a time; the other five lie underneath, constituting hidden value in the form of added resiliency and quality. The number of frames in a Wilton varies from two to six, indicating the thickness of its wool cushion and the number of separate colors in its design. A method known as *planting* makes it possible to add, in small areas, more colors than are indicated by the number of frames.



Worsted Wilton construction shown in detail.


Jute Warp
Cotton Warp Threads
Colored Woolen Yarn
The Various Colored Woolen Yarn buried in the back when not showing in the pattern
Cotton Weft Threads
Jute Warp

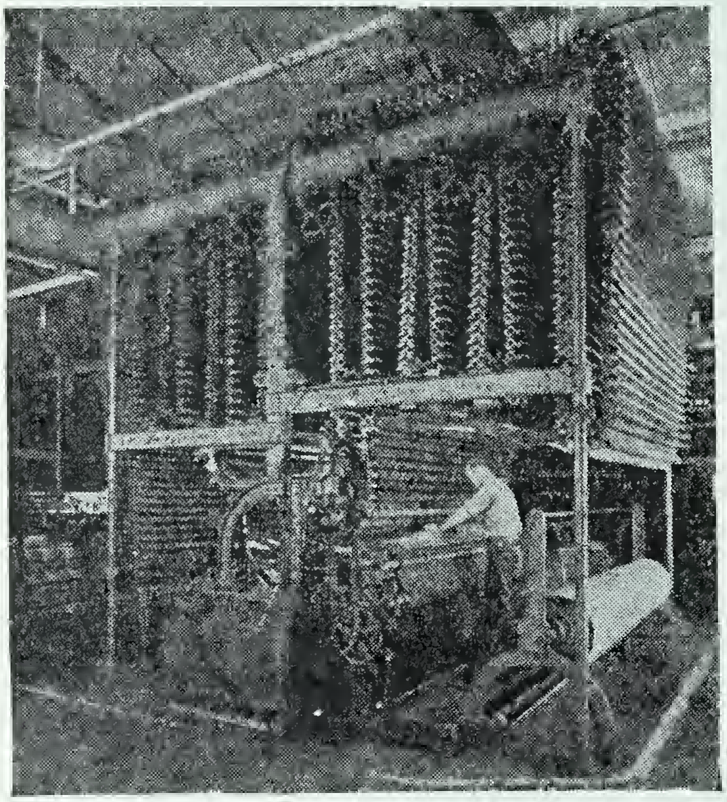
Woolen Wilton construction shown in detail.

The pile effect of the Wilton is produced by looping the surface yarns over wires that have razor-sharp knives at the ends. When the wires are withdrawn, the knives cut the pile.

The Wilton is made with worsted or with woolen yarns. When closely woven, the worsted Wilton offers maximum durability together with fineness of texture and delicacy of design even though it has a short pile. The finest grade of worsted Wilton is woven with six frames, with a three-ply yarn. It has 13 wires to the inch, a three-shot construction, and about 115 tufts to the square inch. Lower grades are woven with a smaller number of frames, have 10 wires to the inch, a two-shot construction, and as few as 60 tufts to the square inch.

The woolen Wilton has a more luxurious feel than the worsted Wilton because of its greater softness and depth of pile. It is made with at least two and a half frames and has 7½ to 9½ wires to the inch and a pitch of 214.

*Saxony.* Saxony is the name given to a better grade of woolen Wilton made from unusually heavily twisted woolen yarns with large and firm tufts. These yarns produce a luxurious depth of pile with large, loose tufts and a coarse design. The rug is especially durable in spite of its extreme softness of texture.



In Axminster weaving, the loom spools are placed in sequence in a continuous sprocket chain to effect the design. One complete revolution of the chain weaves a complete rug or a given number of design repeats in carpet.

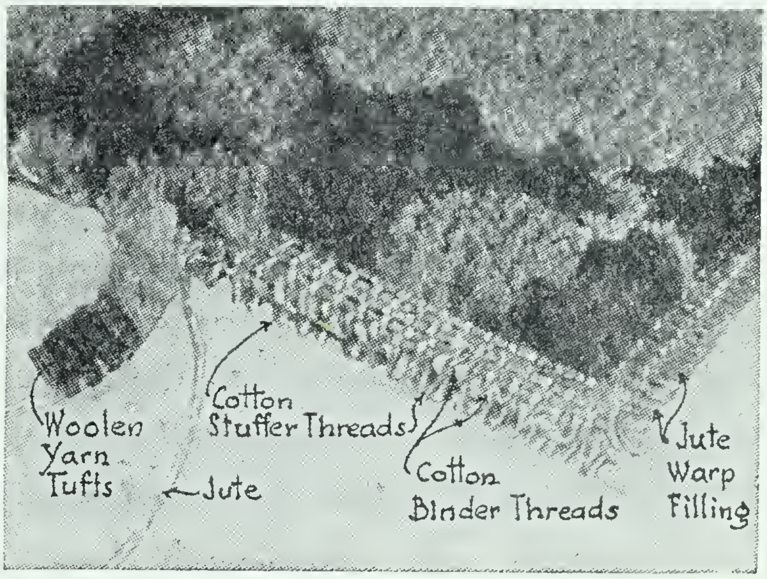
**Brussels.** The Brussels was the first type of carpet to be woven on a Jacquard loom. It is woven like a Wilton except that the wires used to make the surface loops do not have any cutting ends. As the wires are withdrawn, the pile is left as upright loops instead of cut pile. Worsted yarns are used for the pile, the worsted producing a very durable product. The best quality of Brussels is usually woven with five frames and has 9 wires to the inch and a pitch of 256.

**Axminster.** The Axminster rug has been the most popular type of carpet. There is no limit to the number of colors that may be used in its design. The colored yarns are wound on separate loom spools in the weft direction. The spools are fitted in an overhead roller and produce an endless supply of surface yarn. Weeks are required to set the yarns for an Axminster design; but, once arranged, the 9 x 12 size may be woven in only an hour or two. Only woolen yarn is used for the Axminster, as the weave is not tight enough to permit the use of hard-surfaced worsted yarn.

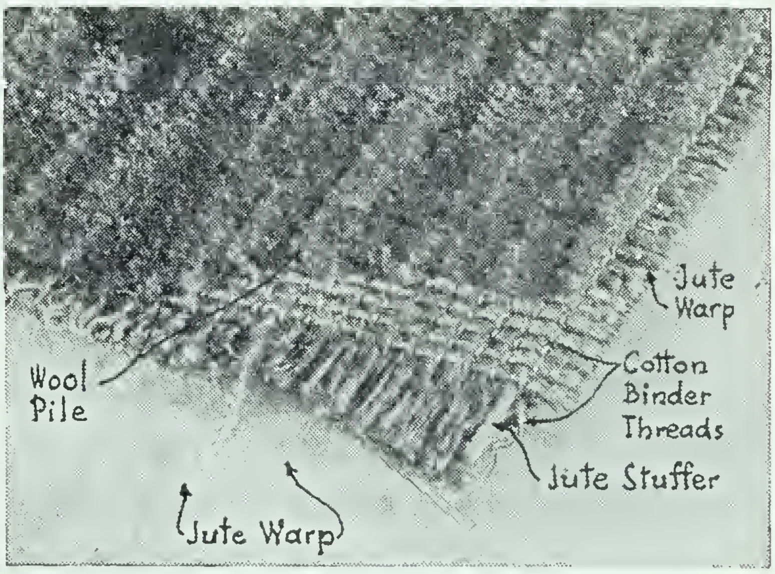
The surface of the Axminster closely resembles hand-knotted carpet, but the Axminster can be easily distinguished from any other type of carpet because it can be rolled only in its lengthwise direction. The stiff jute fibers used in the backing form pronounced ridges on the reverse side.

The better-quality Axminster has a deep pile, some flexibility in its backing, and as many as 70 tufts to the square inch. The less expensive grades have fewer tufts, a low pile, and a very rigid back.

**Velvet.** The velvet construction is the simplest pile weave. Its pile is woven over wires having cutting ends that produce the cut tufts as the wires are withdrawn. All the wool lies on the surface of velvet carpet, with no buried yarns in the backing. Only one yarn is used, and it must be uniform and of good quality throughout in order to absorb the dye evenly when printed. The common method of producing a pattern on velvet rugs is by printing the design after the rug has been constructed. Sometimes yarns that have been printed before weaving are used.



Axminster construction shown in detail.



Velvet construction shown in detail.

The velvet rug is inexpensive, as it is the fastest type to weave. It is made on an ordinary loom, with worsted or woolen yarns. Twisted yarns are used to produce what is known in the trade as hard-twisted velvets. For firmness, jute yarns, sized with glue, are used as stuffing warp yarns. The better-quality velvet rug has a deeper pile; its density should range from 56 to 80 tufts to the square inch.

**Sheen-Type or American Oriental.** The name "American Oriental" is frequently used for the sheen-type or luster-type domestic rugs that are produced by the Wilton, Axminster, or velvet weave. The sheen in the domestic product is obtained by washing or brushing the rugs in a chlorine solution, which imparts the characteristic luster of the imported Oriental rug. The patterns are faithful reproductions and in many cases are woven through to the back, as in the genuine Oriental. When made of good-quality yarns, the American Oriental gives satisfactory wear and has grown in popularity in recent years.

**Tapestry.** The construction of the tapestry rug is similar to that of the velvet except that the wires used to form the pile do not have any cutting ends. Thus an uncut pile is left when the wires are withdrawn. Because of its resemblance to the Brussels type, the tapestry rug is sometimes termed "tapestry Brussels." This is a misnomer. The term attempts to attribute to the tapestry rug the superior construction of the Brussels, which is made on a Jacquard loom with a two- to five-frame construction. The tapestry rug is made on an ordinary loom and requires only one warp yarn.

Tapestry offers the consumer an inexpensive and sturdy product. A good grade should have 8 wires and a pitch of 8. The tapestry rug is not intended for heavy or long wear. It does not have the softness of other rugs, nor does it have delicate or distinct designs. It is intended to satisfy the demand for a low-priced rug.

**Patent-Back Rugs.** In patent-back rugs, each tuft is locked into its place by applying a plastic binder to the back of the rug, or by vulcanizing a solution of rubber cement to the back. Patent-back rugs can be cut in any direction without danger of having frayed edges or raveled yarns; the edges do not require binding. This feature permits the patent-back broadloom to be fitted easily to irregularly shaped areas. Also, holes caused by damage or wear can be cut out and matched pieces put in their places.

**Punched Felt Rugs.** Punched felt rugs have a heavy burlap base reinforced with jute. Over this base is spread a fine-quality wool, which is punched through to the back. Rubber composition is then spread on the back to lock the fibers. This coating gives the rug a cushioned effect and prevents it from slipping.

**Hooked Rugs.** Hooked rugs from the southern and New England states and from Canada are popular as throw rugs for bedrooms and halls. They are handmade of rags, usually reproducing Colonial patterns. Hooked rugs come in various small sizes and are washable.

**Grass Rugs.** A wirelike grass that grows wild in the northeastern section of the United States is used for grass rugs. They are woven with a plain weave that shows on one side; a pattern applied by stencil appears on the other side. Colored warp threads can be used to form geometric designs. Grass rugs are always varnished in order to preserve their surface.

**Sisal Rugs.** Sisal fiber imported from Central America and the West Indies can be made into rugs. The chief use of this fiber is for twine and rope, but its durability makes it adaptable for floor coverings. Sisal fiber is obtained from the leaf of a plant. It is twisted into strands and woven similarly to any of the fiber rugs.

## Imported Rugs

**Oriental.** Very few of the Oriental rugs produced before 1795 are on the commercial market today, but many are displayed in museums. These older Orientals are valuable because of their age, beauty, and intricacy of design. Those made in the last sixty years are accepted as "old Orientals"; although scarce, they are still obtainable.

Oriental rugs are classified according to the country and the section from which they originated. They are divided into six groups: Persian, Turkish, Caucasian, Turkoman, Indian, and Chinese. These groups can be subclassified according to their weave, and also by the method of looping or knot tying that is characteristic of Oriental rug construction.

Only two kinds of knots are used for the many kinds of Oriental rugs made throughout Europe and Asia. The Persian or Senna knot is more of a twist or wrapping; the Turkish or Ghiordes knot is a real knot as understood today.

The largest class of Oriental rugs has a pile surface composed of tufts. Each tuft is made separately by means of the knot formed by strands looped around the warp yarns. When the quality of an Oriental rug is being judged, consideration should be given to coloring, design, depth of pile, quality of the yarn, age, condition, and fineness of texture. The number of knots to the square inch may vary from 50 to 500.

The consumer may find it difficult to distinguish between the imported Oriental and the machine-made domestic product. It may be helpful to remember that the reverse side of the Oriental always shows the entire pattern in detail and that the pile is produced by rows of knots, which can be easily seen by separating the pile. The back should also be examined to see whether the entire pattern has the same colors on the reverse side as are on the face of the rug, and to check the number of knots to the square inch.

In the genuine Oriental, the fringe of the rug is never sewed on; it is always an extension of the warp threads. In proportion to size, the Oriental is always heavier than the domestic. Experienced rug merchants distinguish the two by examining the dyed portion of the pile nearest the knot. Oriental rugs use natural dyes, which usually fade to a lighter shade of the original color. The domestic rug uses aniline dyes, which fade to different hues.

**Chinese.** Antique Chinese rugs were made with the Persian or Senna knot, making possible a large number of knots to the inch and a close shearing of the pile. Later, rugs were made with large coarse designs and a deep pile. In more recent years, Chinese rugs have been made in plain colors as well as in the floral and dragon patterns characteristic of Chinese design. The pile is unusually deep, making these rugs remarkably durable.

**Indian.** Small-sized rugs imported from India are made from felted goat's hair and embroidered by hand with bright wool threads similar to the work found in crewel fabrics. They are known as Numdah rugs. They are inexpensive and adaptable for general household use as they can be easily washed.

Another rug imported from India is woven with the wool of wirehaired sheep; jute is used in its backing. This rug is called a *drugget.* It is usually highly colored and should therefore be dry-cleaned instead of washed.

## Care of Rugs

The appearance and the life of a rug depend on the amount and kind of attention it receives. Dirt and grit must be removed frequently; otherwise, dirt works into the recesses of the pile and into the backing, soon cutting the yarn fibers and finally producing worn areas. A broom, carpet sweeper, or electric cleaner should be used on carpets for a few minutes every day, surely twice a week. All cleaning of this kind should be done in the direction of the pile, not against it.

When sweeping or brushing a new pile-surfaced rug, loose pieces of the pile, or fuzz, are likely to come off. This is caused by the excess short wool fibers worked in during manufacturing operations; it does not necessarily indicate defects. When ends of tufts appear above the surface of a new rug, they should never be pulled out; they should be clipped level with the general surface of the rug.

A new rug or one recently returned from storage should always be swept and brushed gently because the wool in the rug is in a dry condition, not having had sufficient opportunity to absorb its natural intake of moisture. The constant absorption of moisture from the atmosphere, so important for the healthful condition of a rug, keeps it resilient and resistant to wear. Plenty of water should be kept in a room; it may be in fish bowls or in metal containers on the radiators.

A rug should never be shampooed while it is on the floor. It is impossible to clean the pile thoroughly and to rinse out the soap and dirt completely when the rug remains on the floor. A pile rug made with highly twisted yarns should be dry-cleaned; washing or shampooing may untwist the yarns.

Often, constant pressure on certain parts of a rug flattens the tufts or slants them in one direction. The position of the rug should be changed so that the wear may be distributed instead of concentrated in a particular area and so that the uneven shading that occurs when sections of a rug show localized wear may be prevented.

Any stains should be removed promptly. Many spots can be easily removed when they are fresh, whereas removal is difficult when the stain has set. The rules for the removal of spots and stains from general textile fabrics apply as well to textile floor coverings. (See Chapter XVIII.)

Damage from moths may be expected in rugs as in any wool material; but keeping the rug clean and providing a healthful circulation of air reduces the danger. For this reason, some persons do not put their rugs away during the summer months, but let them remain on the floor in order to give them the frequent cleanings so essential for long and serviceable wear. Rugs that are cleaned frequently with a vacuum cleaner are never attacked by moths.

If a damaged area is regular in form, this is an indication that the attacking insect is not the moth but the tow bug, which is likely to be found in overstuffed upholstered furniture. Moths usually show preference for one grade of wool or for a particular color.

Curling of the corner of a rug can be remedied by applying a hot iron on a damp cloth to both face and back of the corner. The curling is usually caused by constant tripping or by some similar unusual strain.

An important safeguard in the care of a rug is to place a cushion backing under it to absorb the constant impact.

*Test yourself on this chapter by answering these questions:*

1. What basic properties of textile fibers are required for floor coverings?
2. What are the two main classifications of floor coverings?
3. What materials are used in making real Oriental rugs?
4. What identifying characteristics distinguish Oriental and Chinese rugs?
5. How does the Brussels carpet differ from broadloom?
6. Describe the Wilton construction. How does a worsted Wilton differ from a woolen Wilton?
7. How can humidity affect floor coverings? How is this indicated to the owner? What remedy is available?
8. Describe the Axminster carpet, showing how the consumer may distinguish it from other carpets.
9. What are the advantages of a chenille carpet? The disadvantages?

10. Compare the imported Oriental with the domestic product.

11. Why is the patent-back construction an important development in carpet production?

12. What are some precautions that a consumer should take in caring for floor coverings?

13. Under what conditions may a wool rug be left on the floor during summer months?

## Suggested Readings

Better Business Bureau, New York, *Facts You Should Know About Domestic Rugs.*

Brinton, R. S., *Carpets.*

Brinton, R. S., *Carpets and Rugs.*

Hess, K. P., *Textile Fibers and Their Use,* Chapter 2, Section 3.

United States Department of Agriculture, Consumer's Guide, Sept. 1939, Vol. 6, No. 7, *Tips for Rug Buyers.*

Wingate, I. B., *Textile Fabrics,* Chapter 17.

## CHAPTER XVIII

# CARE OF FABRICS

Not only should fabrics be carefully selected but they should be given proper care throughout their lives. This care includes: (1) frequent brushing and airing of garments; (2) clean storage when not in use; (3) immediate mending when damaged by tearing; (4) stain removal before washing or further use; (5) intelligent choice of method of cleaning—washing or dry cleaning; (6) frequent laundering when the fabric is washable; (7) use of laundering method proper for the type of fabric; (8) proper pressing and ironing.

**Brushing and Airing.** The frequent brushing of garments, especially those having napped surfaces, removes the kind of dirt that starts out as dust. The accumulation of dust particles not only soils the fabric, even though the soil is not readily discernible, but eventually causes deterioration.

When a garment is not washable, and does not require frequent dry cleaning, very often its life can be prolonged and its appearance kept bright and attractive by brushing. To offset the absorption of perspiration in such garments, they should be frequently aired, outdoors if possible. If outdoor airing is not possible, hanging clothes for a time outside the closet, in a well-aired room, is helpful.

Frequent brushing with a clothesbrush that has soft but firm bristles is necessary to keep wool garments in good condition. Such garments should be hung on wide-shouldered hangers in a closet where clothes are not packed tightly together. Occasional airing is also necessary to prolong the life of wool fiber. Clothes hanging in a closet should always be buttoned, and zippers should be closed.

**Clean Storage.** Clothing that is not in daily use should be protected from deterioration by storage in dustproof containers in which some kind of moth preventive is used. No useful purpose is served if the garment is stored without careful brushing and airing, for accumulated dirt works damage on such stored articles. For long storage, garments should be washed or dry-cleaned and then properly stored immediately, preferably in sealed containers.

If newly purchased linens are to be stored for a while, they should be washed in order to remove any possible sizing. There should be no residue of starch in new or used stored linens as it will cause mildew. If white linens are wrapped in blue paper, and the ends of the package are sealed to exclude light and air, the linens will not turn yellow during storage.

**Mending.** A torn fabric should be mended before further use. Makeshift repair by means of a pin, besides being unattractive, tends to cause a longer tear or fraying, which will be still more difficult to mend. The mended portion will naturally be less noticeable if it is repaired before the surrounding yarns are further damaged.

**Stain Removal.** Successful removal of stains from fabrics depends on the basic principle of not allowing the spot or stain to become set. A stain should be removed at the first possible opportunity because it may be more easily dissolved when fresh.

Different fibers require different methods and different stain removers. Use of an incorrect remover may damage or even destroy the fiber content of a fabric.

**Methods of Stain Removal.** Knowledge of the nature of the stain makes possible the immediate use of the appropriate method and removal agent, and prevents resorting to experimental procedure. Hot water should never be used on an unknown stain; the heat will set the stain, making it more difficult to remove. If the stain is known to be of a nongreasy nature, sponging with cold water may be all that is necessary. On the other hand, a greasy stain requires the use of carbon tetrachloride or some other dry cleaner, such as benzine, gasoline, turpentine, or denatured alcohol.

There are four effective methods for removing spots and stains.

*Dipping.* When the entire fabric can be immersed in the stain remover, the method is called *dipping.* This is the most convenient method if the spot is large or if there are many spots on an all-cotton or all-linen fabric.

*Steaming.* Stains on wool, silk, or any colored fabric may be removed by steaming. The stained area is saturated with steam by spreading the cloth over a bowl partly filled with hot water into which a small amount of the appropriate removal agent has been placed.

*Drop Method.* Small drops of a removal agent can be applied by means of a medicine dropper, glass rod, or orange stick.

*Sponging.* Sponging is the most frequently used method of stain removal; but if it is not done with care, it will not be effective. An absorbent cloth or a blotter should be placed underneath the stain in order to absorb the removal agent as well as the stain. The blotter also prevents further spreading of the wet area. Both the sponging cloth and the absorbent material should be renewed whenever they show the slightest tinge of the stain.

The stained portion of the fabric must not be soaked with the cleaning fluid, and the fabric must not be harshly rubbed. To be effective, small quantities of the fluid must be applied with a soft cloth by light strokes in a circular direction from the outer rim of the stain toward its center. The edges of the stain should be feathered to prevent formation of a ring.

The appearance of a ring indicates an improper method of brushing, an excessive amount of cleaning fluid, or lack of sufficiently quick evaporation. Rapid evaporation can be obtained by blowing upon the fabric or by placing it in front of an electric fan. A ring can be eliminated by holding the fabric over the spout of a steaming kettle until the area is damp; then ironing immediately.

**Stain Removers.** Acids, alkalies, and water are the three types of removal agents. No single chemical can be used to remove all spots from the many different kinds of fibers. For example, acids destroy cotton and linen, and therefore cannot be used to remove stains from these fibers. Similarly, alkalies cannot be used on silk and wool.

Either of the regenerated rayons, viscose or cuprammonium, can be treated like cotton; but acetate rayon requires special care as it dissolves in acetone, acetic acid, and chloroform, or when it is exposed to a hot iron.

Acids and alkalies should be used only as mild solutions. When an acid solution is necessary, any possible damage that might occur to the fabric must be counteracted by applying a weak alkali, such as a solution of bicarbonate of soda or ammonia water, in order to neutralize the acid. The fabric should be thoroughly rinsed in clear water.

If an alkali solution is necessary, it should be followed immediately with a mild acid solution, such as lemon juice, vinegar, or a dilute solution of acetic acid, to neutralize the action of the alkali. The fabric should be well rinsed.

**Bleaching Agents as Stain Removers.** Various bleaching chemicals are commonly used to remove stains, but such chemicals must be used carefully because they extract color and weaken the cloth. Javelle water and other chlorine solutions (sodium hypochlorite) should be used only on cottons, linens, and regenerated rayons—never on silk or wool.

If a stain is to be removed with a bleaching chemical, the fabric should be stretched over a bowl of hot water and fastened around the edge of the bowl. The bleaching agent should be dropped on the stained area with a medicine dropper. This application must be followed immediately with a thorough rinsing. The entire procedure must be done quickly so that the bleaching agent will not remain too long on the material and cause undue weakening of the cloth.

When Javelle water is used, a few drops of oxalic acid or sodium thiosulphate (photographer's hypo) will neutralize the action of any chlorine bleach that may remain in the cloth. If a bleaching agent is used on a colored fabric, the dipping method is advisable in order to avoid unequal distribution of any subsequent loss of color.

Sodium perborate and oxalic acid are effective in removing iron rust, metal stains, and some ink stains from all types of fabrics. These chemicals are the least harmful of all bleaches, but they must be used quickly to prevent abstraction of the dye. For white woolens, sodium perborate is particularly effective and harmless.

For the removal of mildew, ink, iron rust, dye stains, iodine, grass stains, and fruit stains, a solution of a teaspoonful of sodium hydrosulphite in a glass of water is one of the most effective bleaches. But the liquid must be used quickly and the fabric rinsed well; otherwise, the color will be destroyed and the cloth weakened.

Hydrogen peroxide may be used on all kinds of fabrics. It is a mild bleach, but it can be made more effective by the addition of a little ammonia. Oxalic acid and sodium hydrosulphite cannot be used on weighted silk.

Oxalic acid is poisonous if taken internally; it should therefore be labeled so that it will not be mistaken for anything else and placed out of reach.

**Solvents.** Where a stain is known to be of a greasy nature, the use of a solvent alone is sufficient. Grease stains are easily removed by the application of any of the following solvents: carbon tetrachloride, benzine, turpentine, Stoddard solvent, gasoline, ether, acetone, alcohol. With the exception of ether, acetone, alcohol, and colored gasoline, these solvents will not change the color of the material.

Sponging is generally most effective. The solvent should be applied on the wrong side of the fabric. The absorbent cloth underneath the stain will draw the dissolved grease and solvent from the garment.

For fresh grease spots or slight oil stains, a sprinkling of talcum, powdered chalk, or magnesium carbonate (magnesite), rubbed into the stained area and left for a while, will absorb the grease. When the absorbent powder is subsequently brushed off, the stain will be entirely removed. Butter stains can be removed in this manner, but they must first be heated to melt the butter before they can be fully absorbed.

### REMOVAL OF SPECIFIC STAINS

| *Kind of Stain* | *Type of Fabric* | *Procedure and Remover* |
|---|---|---|
| Acid | All | Neutralize with ammonia. |
| Alkali | All | Neutralize with vinegar. |
| Blood | Cotton, linen | Soak in cold water, then in dilute ammonia; wash. |
| Blood | Silk, wool | Sponge with cold water. |
| Butter | All | Sponge with naphtha or with carbon tetrachloride. |
| Candle wax | All | Scrape away; then sponge with benzine. |
| Chewing gum | All | Carbon tetrachloride or ether. |
| Coffee or chocolate | Cotton, linen | Pour boiling water over stain from a height of two or three feet. |
| | Silk, wool | Glycerin, then hydrogen peroxide. |
| Fruit | Cotton, linen | If fresh, pour boiling water through stain. If stubborn, bleach with Javelle water. |

| *Kind of Stain* | *Type of Fabric* | *Procedure and Remover* |
|---|---|---|
| Grass | All | Sponge with alcohol, then with soap and water. |
| Ice cream | All | Sponge with gasoline or with carbon tetrachloride. |
| Iodine | All | Soak in alcohol or boil in solution of sodium thiosulphate. |
| Ink | Cotton, linen | If fresh, soap and water. If dried, use bleach, then oxalic acid, then wash; or put in sweet milk and let turn sour. |
| Ink | Silk, wool | Sponge with hydrogen peroxide, then with oxalic acid or skim milk. |
| Iron rust | Cotton, linen | Oxalic acid, rinse well; or spread with salt, moisten with lemon juice, and place in sun. |
| Lipstick | Cotton, linen | Rub with lard until stain is soft; scrape off grease and wash in hot suds. |
| Mildew | Cotton, linen | Sponge with Javelle water. |
| Milk or cream | All | Sponge with benzine or with carbon tetrachloride. |
| Oil | All | Soap and water or carbon tetrachloride. |
| Paint | All | Soap and water, sponge with carbon tetrachloride or with turpentine on the wrong side of the stain. |
| Perspiration | All | Sponge with peroxide and ammonia. |
| Rubber | All | Sponge with carbon tetrachloride. |
| Rust | All | Sponge with lemon, vinegar, or oxalic acid. |
| Shellac | All | Sponge with denatured alcohol. |
| Scorch | All | If light, dampen and place in sunlight, or sponge with hydrogen peroxide. |
| Sugar | All | Sponge with hot water. |
| Tar | All | Moisten with carbon tetrachloride or with benzine; scrape off, then sponge residue with same solvent. |
| Tea | Cotton, linen | Soak in borax solution, rinse; or keep stain moist with lemon juice, then expose to sun for day or two. |
| Varnish | All | Sponge with equal parts of alcohol and benzine. |

| *Kind of Stain* | *Type of Fabric* | *Procedure and Remover* |
|---|---|---|
| Vaseline | All | Sponge fresh stains with carbon tetrachloride or spread talcum; let stand; then brush. |
| Water spot | Silk, wool | Hold in steam until damp; iron damp. |

**Dry Cleaning.** Many consumers make serious mistakes when deciding whether to wash or to dry-clean a fabric. In general, it is best to abide by the advice of the salesperson who sold the material or by the information concerning cleaning that is sometimes attached by label to a garment or fabric. It is less expensive in the long run to have a garment dry-cleaned, though dry cleaning is more expensive than washing, than to take a chance on washing, and as a result ruin the garment.

If rayon fabric is dry-cleaned at home, the cleaning fluid for acetate rayon must not contain alcohol, chloroform, strong acetic acid, or acetone. Any of these destroy acetate rayon—particularly acetone, which is the solvent used in the acetate process. The commercial dry cleaner identifies acetate rayon by moistening a finger with acetone and rubbing it on some unexposed portion of the fabric. If the threads become hard and feel soaplike, the fabric is acetate.

**Laundering Methods.** When a fabric is known to be washable, frequent and prompt washing is desirable, particularly of clothing worn next the skin. If such garments are not washed after each use, they are more difficult to clean, and the body perspiration that they have absorbed causes the garments to deteriorate while awaiting cleaning.

In general, fine underwear and attractive, brightly colored outer garments and household linens should be laundered at home. Knowledge of how to wash fragile and dainty white garments as well as dyed fabrics is most essential for good results.

Just knowing that a fabric is washable is not enough information for obtaining good results in laundering. The consumer must be acquainted with the proper method for washing each type of garment and fabric. Some fabrics may be subjected to what is termed "hard" laundering without too great a strain on their durability. This type of laundering includes boiling and the use of strong soaps, and it may be done at home as well as in commercial laundries, where it is customary to use strong substances for bleaching purposes and for sanitary reasons.

Before any attempt is made to wash clothes, colored fabrics should be separated from white ones, and heavy work clothes from fine and delicate pieces, as different washing methods are necessary.

If bad stains have not been removed, they must be removed before the fabrics are immersed in the hot water that is generally used for washing. Slightly soiled clothes that do not require soaking should be washed in water not over 115 degrees Fahrenheit; extremely hot water tends to set dirt spots and minor spots or stains that may not have needed special treatment. Clothes that are very soiled should be soaked in warm, soapy water for about ten minutes.

A good quality of household soap should be dissolved in a tub of hot water. Soft water will lather quickly, resulting in a more thorough cleaning. If the water is hard, the soap tends to curd because there is a high concentration of iron calcium, magnesium, and aluminum salts in hard water. Any of the good commercial water softeners may be used to precipitate these soap-destroying metals in the water. Hard water can be softened by the use of washing soda, or sal soda (hydrated sodium carbonate).

**Laundering Cotton Fabrics.** The first requirement in washing cotton fabrics is rich, live suds. If necessary, white cottons may be boiled as well as bleached. Any liquid bleach used in the soap solution should be mixed thoroughly with the water before the clothes are immersed. If white cottons are not too soiled, and if the water is sufficiently hot, sunshine acts as a natural bleaching agent during outdoor drying.

Thorough rinsing in plenty of clear hot water, then in lukewarm and in cooler water, is very important; otherwise, dirt and soap cannot be entirely removed. Rinsing should be repeated until the water is clear.

Where extra whiteness is desired, bluing is used in the last rinse, or it may be used in the wash water in the form of soap flakes containing bluing.

A very hot iron can be used when ironing cottons. For sheer cottons, a moderate iron is advisable. With the exception of napped surfaces, most cottons can be ironed on the right side of the fabric.

**Laundering Linen Fabrics.** Soft water is necessary also when washing linen, and a softener must be used if the water is hard. A mild soap is advisable. Unless absolutely necessary, the soap should not be rubbed directly on the fabric. Stains or spots should be removed before washing so that boiling will not be necessary. White linens may be boiled if they are excessively soiled, but colored linens should be washed only in tepid water.

Linen fabrics should be rinsed thoroughly. For white linens, a little bluing and some powdered borax may be included in the last rinsing. Outdoor drying is ideal for linen.

It is not necessary to starch linen; delicate pieces should never be starched.

Linen should be ironed while it is damp. A natural crispness results, which takes the place of starch. Linen scorches easily; therefore only a moderately hot iron should be used. Ironing on the wrong side of the fabric produces a rough surface on the right side. This surface is preferable in many cases. For a smooth, lustrous surface, iron linen on the right side and with pressure.

The method of folding linen when it is being ironed should be varied because linen fiber is inelastic and may eventually crack at places where the fabric is repeatedly creased. For the same reason fine linens should be rolled instead of folded whenever practicable.

Linen fabrics are weakened by liquid deodorants when these are absorbed into the material. Areas that come in contact with deodorants should be carefully washed and well rinsed; otherwise, ironing will char that portion of the cloth, and it will fall to pieces.

**Laundering Wool Fabrics.** Washable wool fabrics should never be soaked or washed in hot water. Lukewarm water for both washing and rinsing will avoid shrinkage and matting of the fiber. Strong soap hardens the fiber; even mild soaps sometimes have a hardening effect on fine wools. Sulphonated alcohol, which is absolutely neutral and lathers fully in both hard and soft water, is recommended for washing soft, resilient wool.

A dilute solution of hydrogen peroxide (1 pint to a gallon of water) may be used as a bleaching agent; it will not cause loss of color.

Soapsuds should be squeezed into the fabric. Wool fabric should never be rubbed. A wool garment should be kept under water while it is being washed, as the weight of the water will distort the garment if it is lifted out of the water constantly. Wool fabric must never be wrung. After some of the water has been squeezed out of the fabric, it should be rolled in a towel to dry. As direct heat dries out the fiber, causing it to become brittle, wool fabric should be dried at a moderate temperature away from any direct heat, such as a radiator or a stove.

A knitted wool garment should be stretched to its former shape and size and then dried flat. Wool garments should not be pressed too frequently. When pressing is necessary, it should be done on the wrong side with a warm, not hot, iron. Too hot an iron scorches the fibers. To avoid luster caused by the direct heat of the iron, use a press cloth between the iron and the fabric.

**Laundering Silk Fabrics.** Perspiration causes rapid deterioration in silk fabrics; therefore, silk undergarments should be washed in lukewarm water and plenty of soapsuds after each wearing. As strong alkalies destroy silk, strong laundry soap should not be used. For white silk, very mild soapsuds are necessary as strong soap causes white silk to turn yellow. Silk fabrics should be squeezed gently—never wrung—and should be rolled in a towel to remove excess moisture. If the garment is delicate and liable to stretch, it should be dried flat.

The crackling sound called "scroop" that is characteristic of some silk fabrics when they are squeezed or rubbed together can be retained if the fabric is immersed in a dilute acid bath after washing and rinsing. The acid is allowed to dry into the fabric.

Silk should be ironed on the wrong side with a moderate iron; a hot iron fades colored silk and causes white silk to stiffen and turn yellow. Because of a tendency to water-spot, most silks should not be sprinkled before pressing. Spun-silk fabrics, however, may be dampened and ironed on the wrong side.

**Laundering Rayon Fabrics.** When labels are attached to rayon garments, the cleaning instructions given should be followed carefully. If the fabric is washable, only lukewarm water should be used, never hot water. Colored rayons should not be soaked and, of course, should be washed separately. Warm, rich suds of any good neutral soap may be used; cake soap should not be rubbed into the fabric.

The suds must be lightly squeezed into the garment as rayon is not strong when wet. Several rinsings in clear lukewarm water are necessary. The garment should never be twisted or wrung. Roll the garment in a rough towel to absorb the excess moisture. Unroll immediately and allow to dry until still slightly damp. At this point, the garment may be stretched to its original measurements. Rayon should be dried in the shade, never in the sun or close to a radiator or stove.

Rayon garments should be ironed on the wrong side, usually before they are completely dry. The iron should not be very hot, as extreme heat scorches the regenerated rayons and destroys acetate rayon. The regenerated rayons iron better when damp, and acetate when dry. Woven rayon fabrics iron better when slightly damp; knit rayons may be ironed dry.

*Test yourself on this chapter by answering these questions:*

1. In what way does the label on a garment help in caring for the garment?
2. Why should all clothes be placed on hangers when not in use? Why are knitted garments an exception to this rule? Where should knitted clothes be kept?
3. Why is a firm brush recommended for brushing clothing?
4. Why should garments not be crowded in a clothes closet? Why should white garments be kept separate from colored ones?
5. Give illustrations of what is meant by "needed repairs," and give reasons for attending to these without delay.
6. Why should clothes be given a rest? How does this apply particularly to wool clothes?
7. Why should a stain or a spot be removed as soon as it is discovered?

## Suggested Readings

Dyer, E., *Textile Fabrics,* Chapters 10, 12.
Farmers Bulletin, No. 1474, *Stain Removal from Fabrics.*
Hess, K. P., *Textile Fibers and Their Use,* Chapter 3, Section 3.
McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* Chapter 10.
Nystrom, P. H., *Textiles,* Chapter 23.
Woolman, M. S., and McGowan, E. B., *Textiles,* Chapters 14, 15.

# BIBLIOGRAPHY

Bray, H. A., *Textile Fibers, Yarns, and Fabrics,* Century Company, 1939.

Brinton, R. S., *Carpets,* Sir I. Pitman & Sons, Ltd., 1932.

———, *Carpets and Rugs,* Sir I. Pitman & Sons, Ltd., 1932.

Caplin, J., *Knit Fabrics,* Riverside Press, St. Paul, Minn., 1940.

———, *Knitting, Its Products and Processes,* Textile Publishing Company, 1927.

———, *Lace Book,* The Macmillan Company, 1932.

———, *Linen Fabrics,* Riverside Press, St. Paul, Minn., 1939.

Crawford, M. D. C., *The Heritage of Cotton,* Grosset & Dunlap, Inc., 1924.

Darby, W. D., *Cotton, The Universal Fiber,* Dry Goods Economist, 1932.

———, *Silk, Queen of Fabrics,* Dry Goods Economist, 1922.

Denny, G. G., *Fabrics,* Fifth Edition, J. B. Lippincott Company, 1942.

Dickson, H., *The Story of King Cotton,* Funk and Wagnalls Company, 1937.

Dooley, W. H., *Textiles,* D. C. Heath & Co., 1943.

Dyer, E., *Textile Fabrics,* Houghton Mifflin Co., 1923.

Eavenson & Levering Co., Camden, N. J., *Wool Handling.*

Evans, M., *Costume Throughout the Ages,* J. B. Lippincott Company, 1938.

Evans, M., and McGowan, E. B., *A Guide to Textiles,* John Wiley & Sons, 1939.

Haven, G. B., *Industrial Fabrics,* Wellington Sears Company, Rev. Ed., 1941.

Hess, K. P., *Textile Fibers and Their Use,* J. B. Lippincott Company, 1941.

Hoye, J., *Staple Cotton Fabrics,* McGraw-Hill Book Co., Inc., 1942.

Matthews, J. M., *Application of Dyestuffs to Textiles,* John Wiley & Sons, 1920.

———, *The Textile Fibers,* John Wiley & Sons, 1924.

Matthews, M. L., *Clothing—Selection and Care,* Little, Brown & Co., 1936.

Mauersberger, H. R., *American Cotton Handbook,* American Cotton Handbook Company, 1941.

Mauersberger, H. R., and Schwarz, E. W. K., *Rayon and Staple Fiber Handbook,* Rayon Handbook Co., 1937.

McGowan, E. B., and Waite, C. A., *Textiles and Clothing,* The Macmillan Company, 1934.

Miller, M. C., *Principles of Knitting,* McGraw-Hill Book Co., Inc., 1931.

Moore, A. S., *Linen,* Pitman Publishing Co., 1922.

Nichols, H. W., and Broomhead, W. H., *Standard Cotton Clothes and Their Construction,* Dover Press, 1927.

Nystrom, P. H., *Textiles,* D. Appleton-Century Co., 1933.

Page, E., *Lace Making,* Pitman Publishing Co., 1930.

Pellew, C. E., *Dyes and Dyeing,* Robert McBride & Co., 1928.

Schenke, E. M., *The Manufacture of Hosiery and Its Problems,* National Association of Hosiery Manufacturers, 1935.

Schwarz, E. R., *Textiles and the Microscope,* McGraw-Hill Book Co., Inc., 1934.

Small, C. P., *How to Know Textiles,* Ginn & Co., 1932.

Von Bergen, W., and Mauersberger, H. R., *American Wool Handbook,* American Wool Handbook Company, 1938.

Watson, W., *Textile Design and Color,* Longmans, Green & Co., 1931.

Wingate, I. B., *Textile Fabrics,* Prentice-Hall, Inc., 1942.

Woolman, M. S., and McGowan, E. B., *Textiles,* The Macmillan Company, 1943.

## Journals and Pamphlets

American Association of Textile Chemists and Colorists Yearbook, Howes Publishing Company.

American Dyestuff Reporter, *Textile Colorist.*

American Viscose Corporation, *Rayon Fabrics.*

Better Business Bureau Bulletins, Better Business Bureaus in all large cities.

Byron G. Moon Company, New York, general educational pamphlets issued to schools.

Cotton Textile Institute, *Cotton, from Raw Material to Finished Product.*

Du Pont de Nemours & Company, E. E., Inc., Wilmington, Delaware, *Du Pont Magazine.*

Eastman Acetate, *Story of Eastman Acetate.*

Farmers Bulletin, No. 1474, *Stain Removal from Fabrics.*

Journal of the Society of Dyers and Colorists.

National Aniline Company, New York, *Dyestuffs.*

National Retail Dry Goods Association, *Tests to Identify Textile Fibers.*
*Rayon Textile Monthly.*
Textile Economic Bureau, Inc., New York, *Rayon Organon.*
United States Department of Agriculture, Consumer's Guide, Sept. 1939, Vol. 6, No. 7, *Tips for Rug Buyers.*
United States Department of Agriculture, Department of Labor, and Consumer Counsel Division, various publications.
United States Department of Agriculture, Publication 342, *Hosiery.*
United States War Department, *Inspection of Textiles* (TM 10–225).

## ACKNOWLEDGMENTS

The author acknowledges gratefully the permission given by the following organizations for illustrations in this text.

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|---|---|
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